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EFFECTS OF SOIL pH AND TREATMENT LEVEL ON PERSISTENCE AND PLANT UPTAKE OF 2,4,6-TRINITROTOLUENE

by

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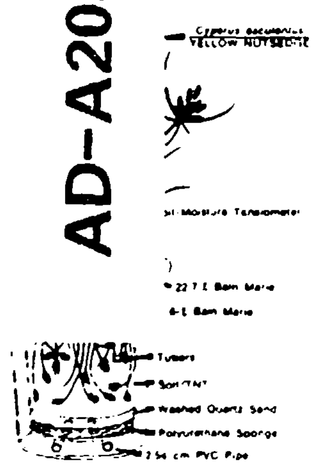

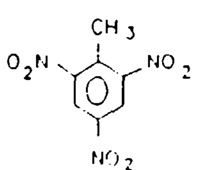

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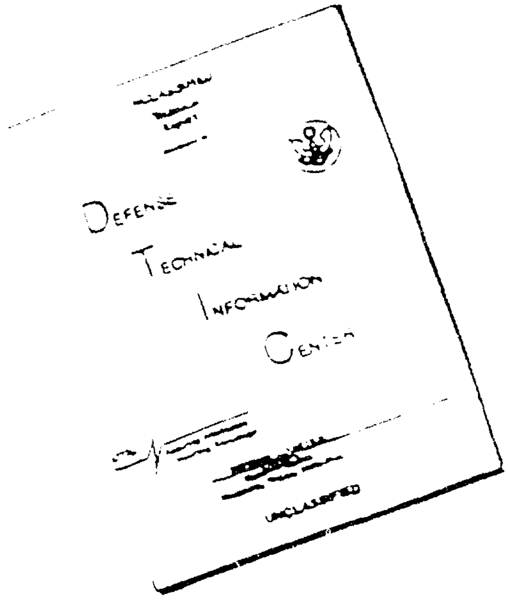

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Two studies were conducted to measure uptake of 2,4,6-trinitrotoluene (TNT) by the ubiquitous yellow nutsedge (*Cyperus esculentus*). The initial study was conducted with three soils treated at low levels of TNT, 20 and 40 μg TNT/g of soil on an oven dry weight (ODW) basis. One of the principal objectives of the initial study was to assess methods for soil treatment, extraction, and analysis. Dry mixing of TNT into the soils resulted in a nonhomogeneous distribution of the compound. Ultrasonic extraction of spiked soils with 200 ml of benzene produced fairly good recoveries of TNT, an average of 80 percent, but coefficients of variation were relatively high. Concentrations of TNT and two of its degradation products, 4-amino-2,6-dinitrotoluene (4ADNT) and 2-amino-4,6-dinitrotoluene (2ADNT), in plants were low. Concentrations of all three compounds were limited to a few micrograms per gram of plant material.

The principal objective of the second study was to determine the effects of soil pH on plant uptake of TNT. Plants were grown in two soils at four pH values (5, 6, 7, and 8) and

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at four treatment levels (0, 100, 200, and 400 μg TNT/g ODW). Plant uptake of TNT from soils was not statistically significant when compared with controls at any treatment level or pH. Although both 4ADNT and 2ADNT were detected in plants, concentrations of neither were significantly different from controls, except for 4ADNT at pH 6 in the US Army Engineer Waterways Experiment Station reference soil (WRS), a Tunica Silt, at the 200-μg/g treatment level. Plant yields tended to decrease as the pH of TNT-treated soils increased. Soil treatment level and soil type exerted a dramatic effect on plant yields. Yields were virtually unaffected by treatment levels in clay. However, in the WRS yields were significantly reduced in the 200-μg TNT/g treatment, and only one of four replicates survived in the 400-μg TNT/g treatment.

Results of soil analysis for TNT, 4ADNT, and 2ADNT at three times during the plant bioassay, i.e. immediately after treatment and 20 days and 65 days after treatment, indicated a rapid decrease in concentrations of TNT in the WRS soil. TNT decreased rapidly from the time of treatment to the first sampling. Some of the loss of TNT is attributable to the production of 4ADNT and 2ADNT, but accumulation of these products did not account for all of the loss. It is likely that volatilization occurred during treatment and for some time after treatment. Between the first and second sampling times, TNT concentrations decreased in the clay as well as in the WRS. Volatilization and soil sorption may account for these results. A decrease was also evident between the second and third sampling times, but it was relatively small and statistically significant in the highest TNT treatments only. Soil concentrations of 4ADNT and 2ADNT rarely exceeded 20 μg/g of soil.

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PREFACE

This study was conducted by the Environmental Laboratory (EL) of the US Army Engineer Waterways Experiment Station (WES), Vicksburg, MS, for the US Army Biomedical Research and Development Laboratory (USABRDL), Fort Detrick, Frederick, MD. The project was authorized by Intra-Army Order No. 82II2032, Change 4, dated 12 February 1985. The research was conducted during the period February 1985 to May 1987.

The study was conducted and the report was prepared by personnel of the Contaminant Mobility Research Team: Dr. Bobby L. Folsom, Jr., Team Leader; Dr. Judith C. Pennington; Ms. Cynthia L. Teeter; Ms. Martha R. Barton; and Ms. Joycie R. Bright. Statistical analyses were provided by Mr. Dennis L. Brandon of the Contaminant Mobility and Regulatory Criteria Group (CMRCG). The study was conducted under the general supervision of Dr. Lloyd R. Saunders, Chief, CMRCG; Mr. Donald L. Robey, Chief, Ecosystem Research and Simulation Division; and Dr. John Harrison, Chief, EL. CPT Henry S. Gardner and Dr. Howard S. Bausum, USABRDL, were Project Managers. Appreciation is expressed to Mr. Richard A. Price, CMRCG, for permission to collect test soils from his farm in Yokena, MS. This report was edited by Ms. Lee T. Byrne of the Information Technology Laboratory, WES.

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EFFECTS OF SOIL pH AND TREATMENT LEVEL ON PERSISTENCE AND PLANT UPTAKE OF 2,4,6-TRINITROTOLUENE

PART I: INTRODUCTION

Background

1. Prior to 1968, 2,4,6-trinitrotoluene (TNT), a primary bursting charge for US Army ammunition, was manufactured by a batch process that produced excessive volumes of waste effluents which, along with wash water from munitions loading, were discharged directly into local streams or settling lagoons. In 1968 the Department of the Army adopted a modified manufacturing process, the continuous flow method, that more completely used raw materials and produced less wastes (Nay, Randall, and King 1974; Leibel et al. 1978). Even though the new process was more efficient, waste effluents still contained as much as 50 to 100 ppm TNT (Traxler 1974). In the 1970s, concern for environmental quality prompted a series of aquatic field surveys of streams that had received ammunition wastes (Fox et al. 1975, Weitzel et al. 1975, Jerger et al. 1976, Sanocki et al. 1976, Stilwell et al. 1976, Sullivan et al. 1977, Putnam et al. 1979). A loss of biological communities downstream from discharges was confirmed. However, TNT could not be implicated exclusively since its degradation products and other contaminants were also present.

2. The aquatic surveys were limited to water quality, fauna, and algae. Uptake by aquatic macrophytes was not examined. It is possible that TNT and its degradation products may be taken up by plants, enter the food chain, and accumulate in animals, where their toxic effects, like those of many pesticides, may be magnified. A study by Schott and Worthley (1974) demonstrated depressed growth of the aquatic plant duckweed (*Lemna perpusilla*) in hydroponic cultures containing 1.0 ppm TNT. Depression of yields in ryegrass by TNT has been cited by Palazzo and Leggett (1983).

3. Hydroponic studies conducted by Palazzo et al. (1985) and Palazzo and Leggett (1986) showed that plant uptake of TNT occurs. In these hydroponic studies, two degradation products of TNT, 4-amino-2,6-dinitrotoluene (4ADNT) and 2-amino-4,6-dinitrotoluene (2ADNT), were found in the plant. Plant uptake of these compounds from soils can be expected to be less than

uptake from solution because of adsorption of TNT and degradation products onto soil particles. Adsorption of TNT is highly correlated with cation exchange capacity, extractable iron, clay content, and percent organic carbon in the soil (Pennington 1987). Soils high in these factors may exhibit limited bioavailability of TNT and its degradation products.

4. The US Army Biomedical Research and Development Laboratory (USABRDL) sponsored an evaluation of the behavior of TNT in terrestrial and aquatic systems as part of an Environmental Quality Technology research effort. Since no data were available with which to assess uptake of TNT from soils by common plant species, the plant bioassays described in this report were conducted. The eventual goal of the USABRDL effort is to develop an overall model to predict movement of polar organic compounds within and between various compartments of the environment.

Objectives

5. Objectives of the study were the following:

   a. To determine the precision and accuracy of soil extraction procedures.

   b. To quantify soil concentrations of TNT, 4ADNT, and 2ADNT during the plant uptake study in order to assess availability of the three compounds to the plant.

   c. To determine effects of soil pH on plant uptake of TNT, 4ADNT, and 2ADNT.

   d. To determine effects of TNT treatment levels on plant uptake of TNT, 4ADNT, and 2ADNT.

   e. To determine effects of TNT treatment levels on plant yield in *Cyperus esculentus*.

PART II: METHODS AND MATERIALS

Initial Study

Soil collection and preparation

6. Three soils were used in the USABRDL study: (a) a Tunica Silt designated US Army Engineer Waterways Experiment Station (WES) reference soil (WRS), (b) a Tunica Silt referred to as "silt," and (c) a Sharkey Clay referred to as "clay." The WRS was collected from a previously selected site within the WES installation, while the silt and clay were collected at Yokena, MS. All soils were taken from areas free from direct application and believed to be free from indirect application of pesticides, fertilizers, and other contaminants for at least 5 years before collection.

7. The soils were placed into 1.2- by 1.8- by 0.15-m drying flats and were mixed daily to facilitate drying. Any debris, such as leaves and twigs, was removed as the soils dried. After air-drying, each soil was ground in a Kelly Duplex grinder (The Duplex Mill and Manufacturing Company, Springfield, OH) to pass a 2-mm stainless steel screen; it was remixed before being stored in steel drums. Soils were mixed each time several shovelfuls were placed into the drums in order to maintain a homogeneous mixture. Four 250-ml bottles of soil were taken from each batch for chemical and physical analyses.

Physical and chemical characterization of test soils

8. Particle size. Particle size was determined on air-dried soils in four replicates using the method of Day (1956) as modified by Patrick (1958). The method determines the percentage of three size fractions in the soil: sand (2 mm- to 50-μm diam), silt (50- to 2-μm diam), and clay (<2-μm diam).

9. pH. Four 10-g samples of each test soil on an oven-dried weight (ODW) basis were weighed to the nearest 0.1 g in 50-ml glass beakers. The soil samples were mixed with 20 ml of reverse osmosis (RO) water until all dry particles were thoroughly wet. The resulting suspension was stirred with a magnetic stirrer for 1 min every 15 min until a total of 45 min had passed. The pH of the suspension was then determined by means of a glass and reference calomel electrode on a Beckman Model SS-3 pH meter (Beckman Instruments Inc., Fullerton, CA). The lime requirement of each soil was determined by the method of Allison and Moodie (1965).

10. Cation exchange capacity. Cation exchange capacity (CEC) was determined in four replicates using the ammonium saturation method of Schollenberger and Simon (1945).

11. Electrical conductivity. Electrical conductivity (EC) was determined in four replicates on extracts of saturated pastes made from soils using the method of Rhoades (1982). The conductivity meter was a Model 31 YSI (Yellow Springs Instrument Company, Yellow Springs, OH).

Soil treatment

12. Fertilization. Experimental units (EUs) were formed by weighing 6.12 kg of soil (ODW) into each of 36 7.6-ℓ Bain-Marie pots (four replicates per treatment). Soil from each EU was transferred to a flat plastic pan for the addition of fertilizer and treatment compound. Fertilization was at the rate of 56-kg nitrogen (N), 28-kg phosphorus (P), and 28-kg potassium (K) per hectare using reagent grade chemicals (N as ammonium sulfate, P as sodium phosphate, and K as potassium chloride, respectively). Fertilization assured adequate nutrition for plant growth.

13. Liming. The WRS and clay required addition of calcium carbonate to raise the pH to 7.0, which is the pH recommended in the WES plant bioassay procedure. The pH of the silt was above 7.0 and therefore did not require addition of calcium carbonate. The lime requirement of an acid soil is the amount of calcium hydroxide or other base required to neutralize the acidity (both dissociated and undissociated) from an initial acid condition to a selected less acid condition (McLean 1982). In most cases, the pH to which the soil should be brought is associated with favorable plant growth (usually considered to be 6.5 to 7.0). The WES plant bioassay procedure (Folsom and Lee 1981) was developed to investigate contaminant uptake under flooded and upland conditions at pH 7.0 or slightly less. Therefore, test soils were brought to pH 7 prior to the plant bioassays.

14. TNT treatment. Soil treatment levels of TNT (Eastman Kodak, Inc., Rochester, NY) were 20 and 40 μg TNT/g of soil or 122.4 and 244.8 mg TNT/EU. The TNT was carefully ground to a fine powder in a porcelain mortar and pestle before being well-mixed with the fertilizer and lime. TNT for each EU was mixed into the soil by hand as described in the following paragraph.

15. The fertilizer, lime, and TNT treatment were sprinkled evenly over the entire surface of half the soil for each EU in the plastic pan and mixed in with gloved hands. The remaining soil was sprinkled over the mixture and

also mixed in by hand. The container from which the fertilizer, lime, and TNT mixture had been taken was rinsed by placing a handful of soil into the empty container and shaking to collect any mixture that adhered to surfaces. The rinse was returned to the pan, and the soil was again thoroughly mixed.

Plant bioassay

16. Soil sampling. Soil was separated into four parts while still in the plastic pan, and a 250-ml sample was collected from each quarter. These samples were combined, thoroughly mixed, and placed in 1-ℓ sample bottles before being frozen (-40° C), packed in ice, and shipped via air freight to the Tennessee Valley Authority (TVA) Analytical Laboratory, Chattanooga, TN, for chemical analysis. These samples constituted the time = 0 (T0) samples.

17. WES plant bioassay. A schematic diagram of the standard WES plant bioassay apparatus is shown in Figure 1 (Folsom and Lee 1981). A 7.6-ℓ plastic Bain Marie pot rests on two 2.54-cm polyvinyl chloride (PVC) pipes inside a larger (22.7-ℓ) outer Bain Marie pot. Six holes 6.35 mm in diameter were drilled in the bottom of the inner pot to allow water movement. A 2.54-cm polyurethane sponge was placed in the bottom of the smaller pot and then overlaid with 2.54 cm of washed quartz sand. The sand and sponge served as a filter to prevent soil from draining out of the inner pot.

18. A soil-moisture tensiometer (Model 506M, Irrometer Co., Inc., Riverside, CA) was placed into each EU. Soil moisture of all treatments was maintained between 0.03 and 0.05 MPa (30 to 50 percent of field capacity, i.e., field capacity equals 0.00 MPa) with deionized water obtained from a Continental Model 3230 Reverse Osmosis water system (Continental Water Conditioning Company, Jackson, MS).

19. The treated soil was returned to the Bain Marie pots, randomly located on benches in a greenhouse, and allowed to equilibrate for 20 days. The greenhouse temperature was maintained at a daytime maximum of 30° C and a nighttime minimum of 21° C. Since the natural day length varied from slightly more than 11 hr to slightly more than 13 hr, supplemental lighting was used to maintain the 16-hr day length required for maximum vegetative growth of *C. esculentus*. A photosynthetic active radiation level of 1,300 microEinsteins/m^2/sec was maintained during the 65-day period of the experiment.

20. After 20 days (T20), four representative core samples 30 cm long by 2 cm in diameter were taken from each EU. Each of the four cores was placed into a plastic tray and thoroughly mixed by hand. The mixed samples were then

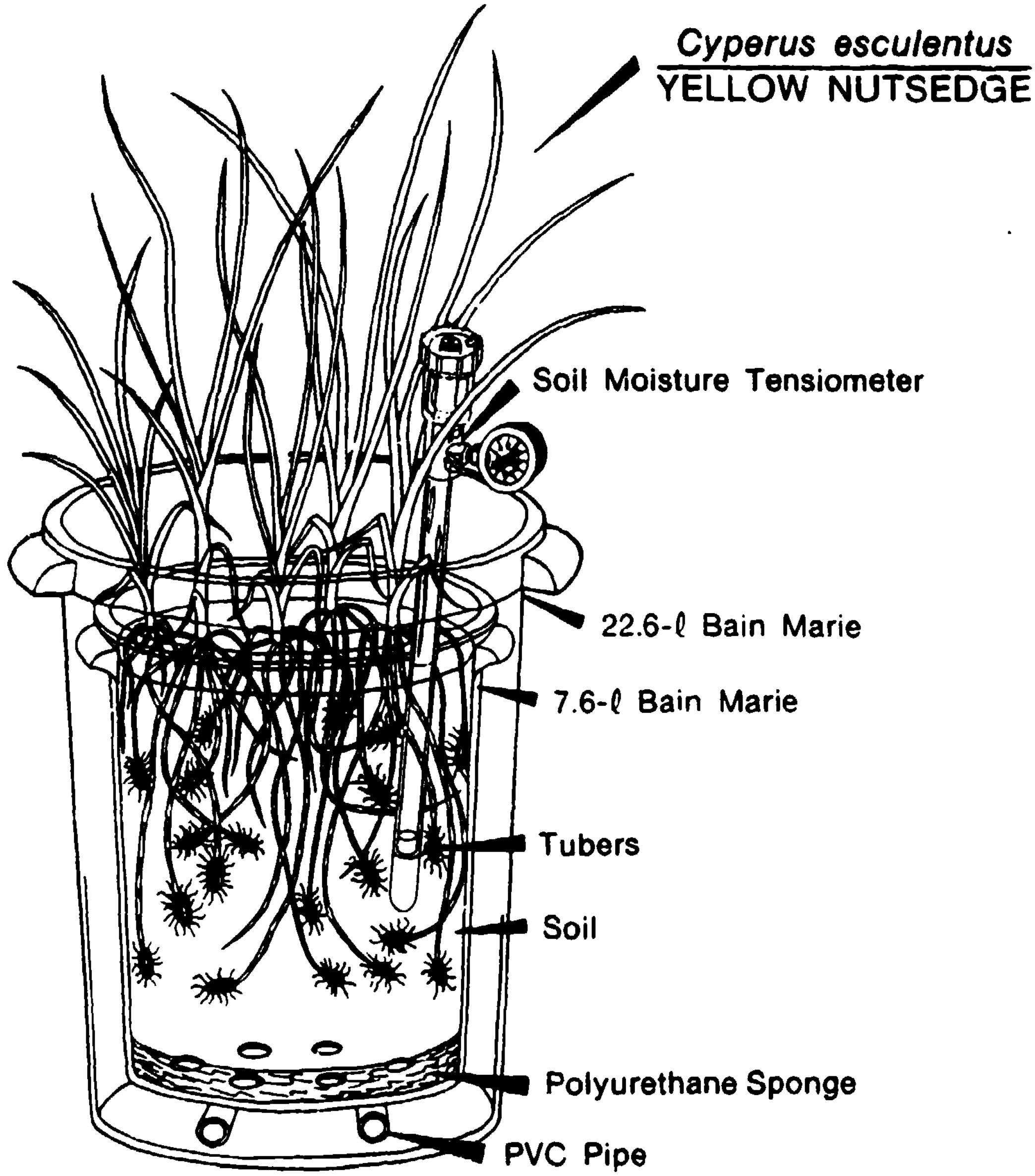

Figure 1. Schematic diagram of the WES plant bioassay experimental unit

placed into 250-ml plastic bottles, frozen (-40° C), packed in ice, and shipped via air freight to TVA for analysis. At 20 days each EU was planted with three tubers of *C. esculentus*. Plants were allowed to grow from February to mid-April 1985.

21. Plants were watered when tensiometers read greater than 0.05 MPa. Deionized RO water was used to fill the outer pot to the top of the soil in the inner pot. When tensiometers read less than 0.03 MPa, water was siphoned from the outer pot. Tensiometers were monitored daily.

22. Harvesting. Forty-five days after planting, i.e., 65 days after soil treatment (T65), plants from each EU were cut 5 cm above the soil surface with stainless steel scissors and rinsed by being sequentially submersed in two containers of RO water to remove any soil particles. Plant leaves were blotted dry, placed into a labeled plastic bag, and sealed. Controls (0 μg TNT/g) were harvested first, the 20-μg-TNT/g treatments second, and the 40-μg-TNT/g treatments last. After harvest, the researcher emptied the soil from each EU into a plastic tray by turning the inner pot upside down and gently tapping the bottom. After the sponge, sand, and any remaining plant material (i.e. roots) were discarded, the soil from each pot was thoroughly mixed by hand to obtain as homogeneous a mixture as possible and was sampled as previously described for sampling after initial mixing (paragraph 16). Plant and soil samples were frozen and sent to TVA for analysis.

Sample analysis

23. Soils. Soil samples were analyzed for TNT, 4ADNT, and 2ADNT. Compounds were extracted from 10-g soil samples (ODW) with 200 ml of benzene in an ultrasonic cell disrupter (Heat Systems Ultrasonic, Farmingdale, NY) operated at full power for 5 min. An aliquot of the supernatant was injected into a gas liquid chromatograph (GLC) (Hewlett Packard Model 5880, Palo Alto, CA). The GLC was equipped with a BD-5 column (J and W Scientific, Folsom, CA) programmed at 150° to 280° C at 10° C/min increments. An electron capture detector was used.

24. Plants. Before plants were frozen, subsamples were taken for determination of yields. The subsamples were weighed, oven dried (70° C), and reweighed. The remaining plant samples were frozen and shipped to TVA, where they were thawed, extracted with benzene, and analyzed by GLC, using the same procedure applied to soils.

Data analysis

25. Levene's Test for homogeneity of variances was performed (Brown and Forsythe 1974) prior to analysis of variance (ANOVA). If the results indicated that variances were not homogeneous, a nonparametric procedure was used. In such cases, data were ranked by means of the PROC RANK procedure available in the Statistical Analysis System (SAS) (SAS Institute, Inc. 1985), and an ANOVA was performed on these ranked data to test for differences between groups. If the results of Levene's Test indicated that variances were homogeneous, an ANOVA was performed on means. When the results of ANOVA indicated

that it was necessary to reject the null hypothesis ($P < 0.05$), Duncan's New Multiple Range Test or Waller-Duncan k-Ratio t-Test (Steel and Torrie 1980) was used to determine differences among treatments. When the results of the chemical analysis were less than detection limits, values were set equal to detection limits for inclusion in data analyses.

pH Study

Soil preparation and treatment

26. The methods of collection and preparation as well as chemical and physical characterization of test soils for the pH study were the same as those for the initial study with several exceptions. In the pH study only the WRS and clay were used, and 4.5 kg rather than 6.12 kg of soil was used. Four pH levels were tested: 5, 6, 7, and 8. All soil pH values used in the study were produced by liming the soil, except for pH 5 in the clay. Since the pH of the clay (5.71) exceeded the desired value of 5.0, adjustment with acid was required. The procedure of the lime requirement test using sulfuric acid instead of calcium hydroxide was employed to determine the amount of acid needed. Sulfuric acid was added as a dilute solution to the appropriate soil treatments when amendments were added. Soils were treated with the following three concentrations of TNT at each of the tested pH values: 100, 200, and 400 µg TNT/g of soil (ODW). These treatment levels were equivalent to a total of 529, 1,059, and 2,118 mg TNT/EU. Treatment solutions were prepared in 50 ml of methanol. After the addition of fertilizers and lime or acid, TNT solutions were brought to a volume of 350 ml with additional methanol and sprinkled over the soil. After the addition of three methanol rinses from the container, the soil was mixed thoroughly by hand. T0 soil samples were collected for analysis as described in the initial study.

Plant bioassay

27. Planting, sampling, and harvesting followed the same plant bioassay procedures used in the initial study. Controls were always handled before treatments, and treatments were handled in order from lowest to highest concentrations. Pots were positioned in the greenhouse in a completely randomized design.

Sample analysis

28. Soil and plant samples were analyzed for TNT, 4ADNT, and 2ADNT. An extraction procedure (method No. 8H) developed by the US Army Toxic and Hazardous Materials Agency (USATHAMA) (1983) was used to extract the soils. The procedure was developed for use with analysis by high-performance liquid chromatography (HPLC) and was not designed to separate 4ADNT from 2ADNT. However, it was employed in the pH study in an attempt to improve recovery of treatment compounds from the soil. An aliquot of the extract was injected into the GLC, with the same operational conditions being used as described previously. Plant tissues were extracted with an ultrasonic cell disrupter and analyzed by GLC as described for the initial study. Plant yields were also determined as described for the initial study.

Data analysis

29. An ANOVA was performed on the data to test for differences among treatments (F-Test). In cases where the null hypothesis was rejected, the Waller-Duncan k-Ratio t-Test (Steel and Torrie 1980) or orthogonal contrasts (Winer 1971) were used to determine differences among treatments. The probability of a Type I error was <0.05 throughout in both the F-Test and in the multiple comparison tests. Statistical analyses were performed using the ANOVA procedure available with SAS (SAS Institute, Inc. 1985). Whenever analytical results in soils data were less than detection limits, values were set equal to detection limits. Whenever analytical results in plant data were less than detection limits, values were set at zero.

PART III: RESULTS AND DISCUSSION

Initial Study

Physical and chemical characteristics of test soils

30. Physical and chemical characteristics of the test soils are presented in Table 1. Particle-size distribution of the WRS and the silt did not differ from each other, but both differed from the clay. Clay content was more than four times greater in the clay than in either the WRS or the silt.

31. The pH of the WRS and the clay were initially acidic (pH < 7), whereas the silt was basic (pH > 7). The CEC of the clay was almost three times that of the WRS or the silt. The organic matter content of the soils followed the pattern of clay > silt > WRS.

Percent recoveries of TNT from T0 soils

32. An objective of this study was to determine the efficiency of the extraction procedure by comparing the amount of TNT added with the amount extracted from the soils. This procedure does not take into account the possibility of loss of treatment compound from the soil, as discussed in paragraphs 41 and 42. Percent recoveries and standard deviations for T0 soils are presented in Table 2. The fact that standard deviations were fairly high for all soils and treatment levels suggests that the TNT was not homogeneously distributed throughout the soil. Recoveries averaged 75 percent.

Precision and accuracy of analytical techniques for soils

33. Percent recoveries of TNT, 4ADNT, and 2ADNT spikes from test soils with their respective coefficients of variation are presented in Table 3. Coefficients of variation were fairly high, indicating that the precision of the analytical technique was less than ideal. Percent recoveries varied with assayed compound and indicated that accuracy was also less than desired.

Soil analysis

34. Results of TNT, 4ADNT, and 2ADNT analysis of soils at the three sampling times (T0, T20, and T65) are presented in Table 4. Variances for the data set were not homogeneous; therefore, data were subjected to nonparametric analysis. Analysis of the soils immediately after treatment with TNT (T0)

revealed that an average of 75 percent of added TNT was recovered. This result may be due to inefficiency of the extraction method or to loss of the treatment compound through volatilization from the methanol during soil treatment.

35. Every soil at every TNT treatment level exhibited a conspicuous rise in the concentration of 4ADNT with time. This result suggests conversion of TNT to 4ADNT in the soils. Very little 2ADNT was detected in the soils over time. The only exception was 15.9 μg 2ADNT/g of soil in the 40-μg-TNT/g clay treatment at T20. Results of this study do not suggest any conspicuous differences in the behavior of TNT with soil type. Chromatograms indicated no compounds other than TNT, 4ADNT, and 2ADNT.*

Plant analysis

36. Concentrations of TNT, 4ADNT, and 2ADNT found in plant material are presented in Table 5. All three compounds were found in plant leaves; however, concentrations were generally limited to a few micrograms per gram. Variances in the plant data like that in the soils data lacked homogeneity according to Levene's Test (Brown and Forsythe 1974). Trends in the data suggest that 4ADNT is more readily mobilized into the plant than TNT or 2ADNT. Significant plant uptake of 4ADNT occurred at 40 μg TNT/g in all three soils, and significant uptake of 2ADNT occurred at 40 μg TNT/g in the WRS and the clay.

Plant yields

37. Yields of *C. esculentus* in the initial study are presented in Table 6. Yield data for the 20-μg-TNT/g treatments were lost. Plant growth was unaffected by the presence of TNT in any of the three soils. Very little difference between plants from the various treatments was visible (Figure 2).

pH Study

Physical and chemical characteristics of test soils

38. The WRS and clay used in the initial study were selected for use in the pH study. However, since it was necessary to collect new batches of the

* Personal Communication, 24 July 1985, Dr. Barney Neal, Analytical Chemist, TVA Laboratory, Chattanooga, TN.

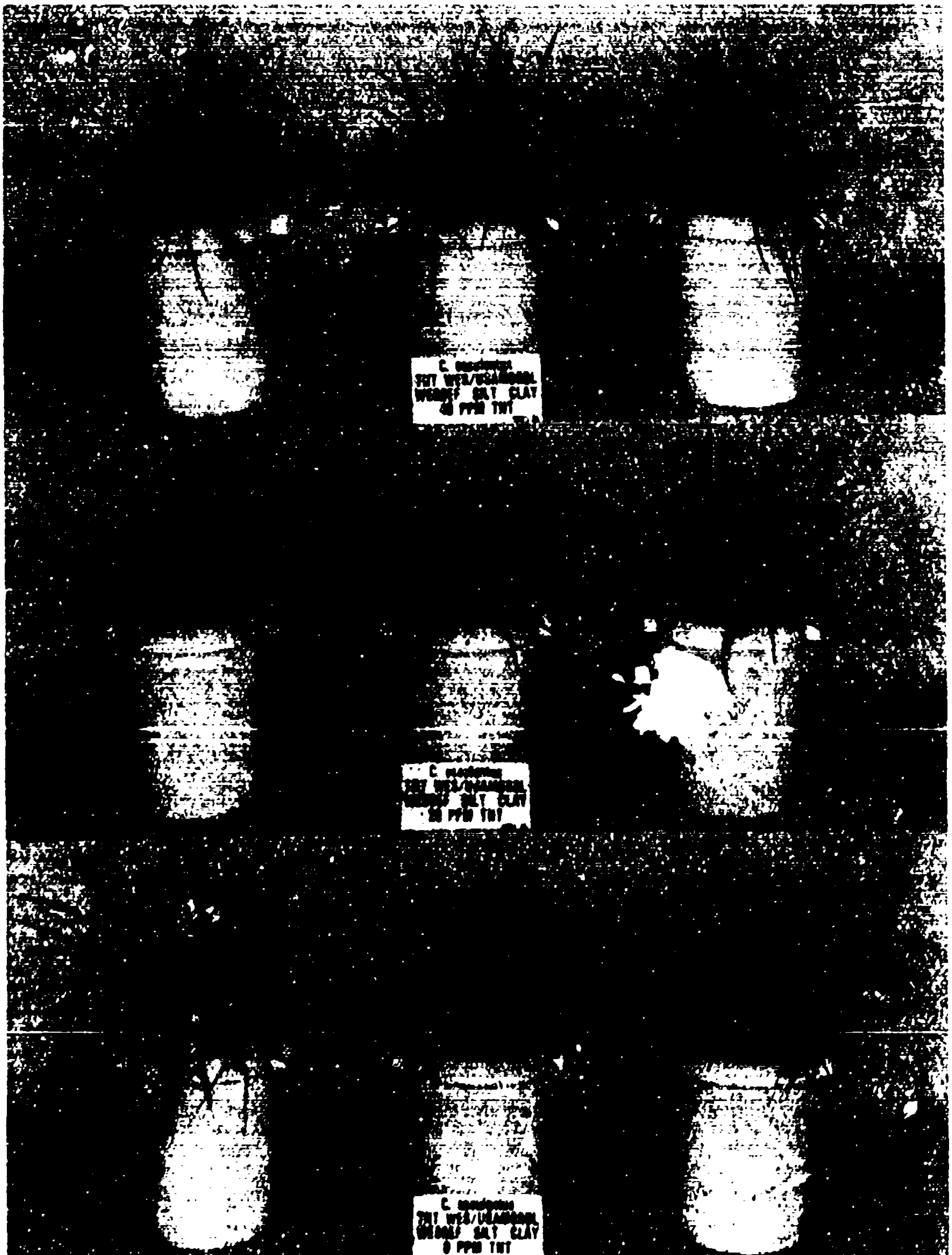

Figure 2. *Cyperus esculentus* grown in the WES plant bioassay conducted with WRS, silt, and clay treated with 40, 20, and 0 μg TNT/g of soil (ODW) in the initial study

soils, physical and chemical tests were repeated (Table 7). Results of analyses indicated little difference between the batches. However, the clay of the second batch exhibited a much higher CEC, and the WRS contained more clay and less sand than soils used in the initial study.

Percent recoveries of TNT from T0 soils

39. Effects of soil type and pH. Percent recoveries of TNT from soils in the pH study at T0 are presented in Table 8. Recoveries from WRS ranged from 74.0 to 90.0 percent (mean = 82.6) and were less than those from clay which ranged from 83.8 to 120 percent (mean = 98.1) except at the 400-μg/g treatment level, where there was no difference between the two soil types. Soil pH did not affect recoveries of TNT from the WRS; however, recoveries from the clay tended to decrease as soil pH increased, especially at pH 8. Spanggord et al. (1980) found that aqueous solutions of TNT under neutral or acidic conditions remained very stable in darkness; however, at a pH value of 11.1, TNT decomposed even in darkness. It is possible that TNT decomposes at pH 8 in the clay and that some is lost from the soil. However, reduced extractability resulting from increased adsorption to the clay is also possible. Coefficients of variation within the soils data of the present study were generally less than 10 percent.

40. Effects of treatment levels. Percent recoveries of TNT were affected by TNT treatment levels (Table 9). Recoveries from WRS were less from the 100 than from either the 200- or 400-μg/g treatment. Recoveries from clay were generally less from the higher treatment levels. Reduction in extractability resulting from soil adsorption of TNT is a more important factor in the clay than in the WRS (Pennington 1987). Once soil sorption sites are saturated, excess compound may be subject to decomposition or volatilization, especially at higher pH values.

Precision and accuracy of analytical techniques for soils

41. Precision and accuracy of the USATHAMA method (Table 10) were considerably better than those of the extraction method used in the initial study (Table 2). Precision was better for 4ADNT and 2ADNT than for TNT, but accuracy was excellent for all three compounds.

Concentrations of TNT,
4ADNT, and 2ADNT in soils at T0

42. Loss of TNT from treated soils. Analysis of the soils immediately after treatment (T0) revealed concentrations of TNT significantly greater than controls (Table 11); however, concentrations of TNT were less than nominal in the WRS. Losses from the WRS averaged 25, 13, and 15 percent for the 100-, 200-, and 400-µg/g treatments, respectively. Relatively little TNT was lost from the clay (0, 3.5, and 7 percent at the 100-, 200-, and 400-µg/g treatment levels, respectively). Although soils at T0 exhibited concentrations of 4ADNT and 2ADNT high enough to account for most losses from the clay (Table 11), levels were insufficient to account for losses from the WRS. No compounds other than TNT, 4ADNT, and 2ADNT were detected in the soils.* These results are illustrated in Figures 3 and 4 for the WRS and clay, respectively.

43. Two possible explanations for these results are lack of extractability of TNT from soils because of strong adsorption and loss of TNT from the soils through some volatilization mechanism. In a similar study using carbon 14-labeled TNT and 4ADNT and the same two soils used in the present study, Pennington (1988) found similar losses. When results from complete combustion analysis of the soils for recovery of the carbon 14 were compared with results using an extraction technique, lack of extractability accounted for 56 and 27 percent of the TNT in the clay and WRS, respectively. These results were consistent with soil sorption studies conducted with the same soils; this consistency indicated that adsorption was greater in the clay than in the WRS (Pennington 1987). In the present study, reduced extractability resulting from adsorption probably accounts for some of the reduction in recoveries of TNT from the soils. This evidence indicates that reduced extractability should be greater in the clay than in the WRS. Since this was not the case at T0, lack of recovery from the WRS so soon after treatment may have been due to loss of TNT via volatilization. If volatilization of TNT or its degradation products occurred from the soil, greater loss from WRS than from clay would be expected because of increased adsorption to clay and because WRS, having a larger particle size than clay, is less densely packed.

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* Personal Communication, Dr. James Bobo, Analytical Chemist, Tennessee Valley Authority Laboratory, Chattanooga, TN.

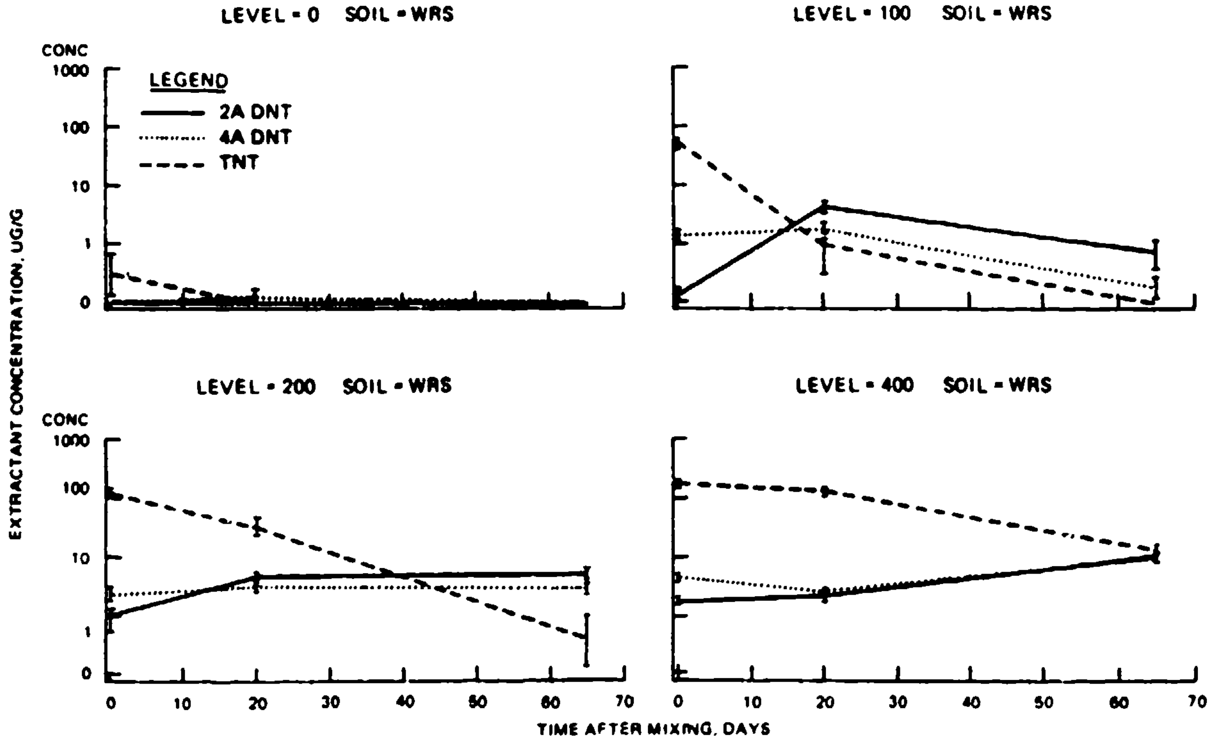

Figure 3. Changes in concentrations of TNT, 4ADNT, and 2ADNT in WRS at each treatment level (averaged over all pHs) through time

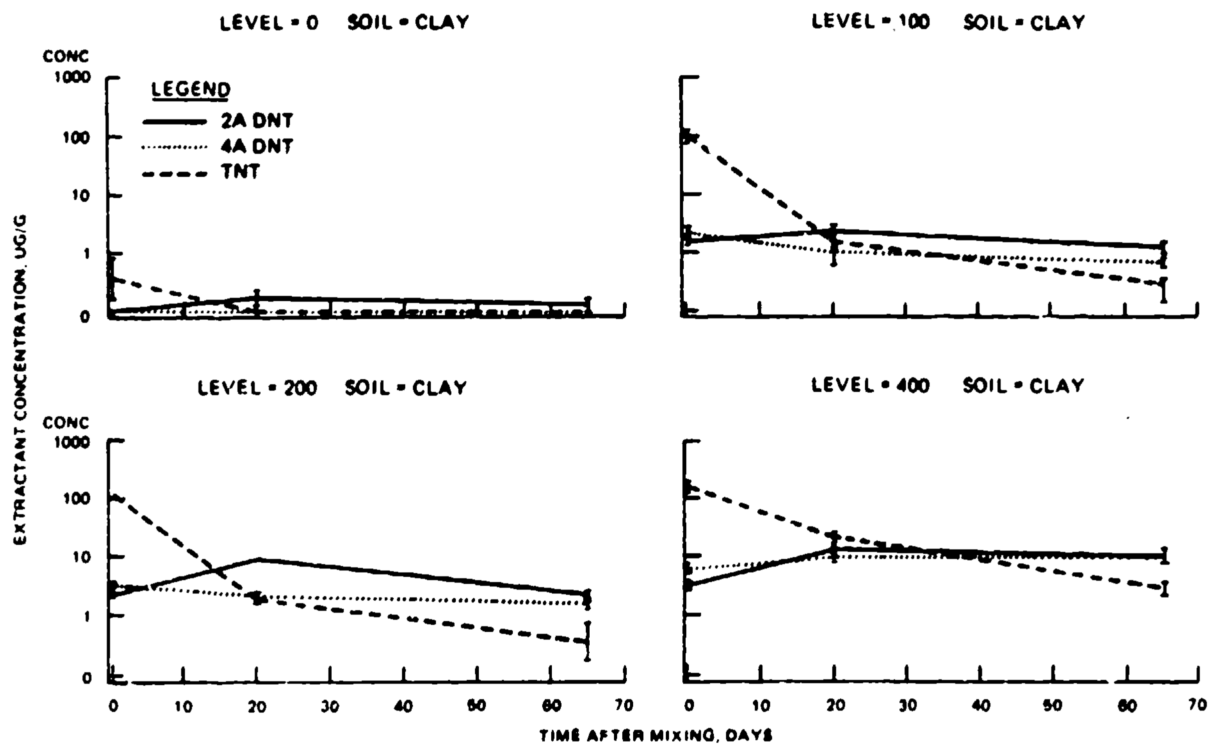

Figure 4. Changes in concentrations of TNT, 4ADNT, and 2ADNT in clay at each treatment level (averaged over all pHs) through time

Decreased density would allow greater contact between TNT and soil solution and between TNT and air pockets in the soil, potentially increasing loss. Recent evidence (Miller, Hebert, and Zepp 1988) indicates that low-volatility organic compounds can migrate upward through the soil to the surface. Migration is enhanced by the presence of organic solvents in the soil. At the surface photodecomposition occurs, and volatilization of the compounds from the soil results in surface depletion and additional upward migration of the compounds. The presence of methanol, the organic solvent used during soil treatment in the present study, together with application of water from the bottom to the top of the soil column, could promote photodecomposition and subsequent volatilization of TNT from the soils in a similar manner. Accumulations of a reddish-brown coating over the soil surface were visible in some pots late in the study. Several TNT degradation products are reddish orange in their pure form and could be responsible for the coloration of the soil surface, e.g., 2,4-diamino-6-nitrotoluene; 2,6-diamino-4-nitrotoluene; 2,4-dinitrotoluene; 2,6-dinitrotoluene; and 1,3,5-trinitrobenzene.

44. Effects of pH and soil type. The pH exerted no statistically significant effect on soil concentrations of TNT in the WRS (Table 12). In the clay where differences occurred, TNT concentrations tended to decrease with increasing pH. The pH exerted little effect on soil concentrations of 4ADNT and 2ADNT. When differences occurred between soil types, clay contained more TNT than did the WRS. Few differences in 4ADNT concentrations occurred between soil types, but when they did, clay contained more 4ADNT than did WRS. The clay consistently contained more 2ADNT than did WRS, but concentrations of 2ADNT were lower than concentrations of 4ADNT or TNT.

Concentrations of TNT, 4ADNT, and 2ADNT in soils at T20

45. Concentrations of TNT, 4ADNT, and 2ADNT in soils sampled 20 days after treatment (T20) are presented in Tables 13 and 14. TNT concentrations extracted from the soils at T20 generally increased with treatment levels. However, in the clay at pHs 7 and 8, TNT concentrations did not differ from controls even in the highest treatment levels. Concentrations of 4ADNT and 2ADNT were greater than controls, except for the concentration of 2ADNT in the WRS treated with 400 μg TNT/g at pH 6, which showed no difference from the control. Soil concentrations of TNT decreased significantly with increasing pH in the 400-μg/g treatment of clay and WRS, but pH exerted little effect at

lower treatment levels (Table 14). Generally, 4ADNT and 2ADNT decreased with increasing pH where pH effects were evident. Concentrations of 4ADNT and 2ADNT were higher in the WRS than in the clay in the 100-μg/g treatment, but these concentrations were lower in the WRS than in the clay in the 400-μg/g treatment.

Concentrations of TNT, 4ADNT, and 2ADNT in soils at T65

46. Concentrations of TNT, 4ADNT, and 2ADNT in soils at T65 are presented in Tables 15 and 16. Concentrations of TNT were uniformly low and typically no different from controls, except at the highest treatment level. Both 4ADNT and 2ADNT were consistently greater than controls and generally increased with TNT treatment levels. Concentrations of TNT were unaffected by pH (Table 16), except in the WRS at the 400-μg/g treatment, where relatively high concentrations persisted; here TNT concentrations decreased with increasing pH. Generally, 4ADNT decreased with increasing pH. Effects of pH on 2ADNT concentrations in the WRS were negative or inconsistent; however, in the clay, 2ADNT concentrations were highest at pH 5 in the 200- and 400-μg/g treatments. The two soils differed little in TNT, 4ADNT, and 2ADNT concentrations. When differences occurred, concentrations were usually higher in the WRS.

Concentrations of TNT, 4ADNT, and 2ADNT in soils over time

47. TNT concentrations decreased significantly at all treatment levels and soil types from T0 to T20 (Table 17). The highest two treatment levels of WRS continued to decrease from T20 to T65, while only the highest level of clay at pHs 5 and 6 continued to decrease. Even in T0 soils, 4ADNT and 2ADNT were present in quantities significantly greater than those of controls (Table 11). However, concentrations of the degradation products were not sufficient to account entirely for the observed decreases in TNT. Therefore, it is likely that adsorption continued until some maximum saturation of the soil occurred or that mechanisms of loss from the soils continued during the test period.

48. Tables 18 and 19 show soil levels of 4ADNT and 2ADNT, respectively, through time. Concentrations of 4ADNT tended to reach a maximum at T20 in the WRS at the lowest treatment levels, but at T65 in higher treatment levels. In the clay 4ADNT concentrations decreased from T0 to T65 except at the highest

treatment level, where there were no differences or an increase after T20. Concentrations of 2ADNT tended to reach a maximum at T20, except in the 400-μg/g-treated WRS, where greatest concentrations of 2ADNT occurred at T65.

Plant analysis

49. Concentrations of TNT, 4ADNT, and 2ADNT found in plant tissues are presented in Tables 20 and 21. Treatments exhibited no more TNT than controls in either of the soils (Table 20). This result indicates that TNT was not taken up by the plants. Results for 4ADNT and 2ADNT were the same as those for TNT, except for an increase in 4ADNT in the 200-μg/g treatments of WRS at pH 6. However, actual uptake was no greater than in soils having other pH values (Table 21).

50. The presence of TNT in control plants raises the possibility of contamination. However, the uniform distribution of TNT through all replicates (see data in Appendix A) suggests that the values found are an artifact of the analytical method rather than contamination of the tests. The plant extraction procedure employed no cleanup procedure other than decanting of extract from the plant material. Therefore, extracts contained any soluble organic compounds present in the plant. If compounds having retention times similar to TNT were present, they may have been identified as TNT in the single column GLC analysis performed. A second GLC column having a slightly different retention time run simultaneously with the first would have resolved any such interferences. If interferences were responsible for TNT values in controls, they could also interfere with detection of low levels of TNT in treatments. Treatments differ so little from controls that plant uptake was limited even if control values are considered as background. Neither 4ADNT nor 2ADNT was found in control plants. Therefore, the low concentrations of these degradation products are more reliable, but the concentrations detected were rarely significantly different from controls. 4ADNT was detected more often than 2ADNT and generally in higher concentrations.

Plant yields

51. Although TNT apparently was not taken up by *C. esculentus*, plant growth was affected significantly by TNT treatment level (Table 22). In the WRS there was no difference between yields for controls and for 100-μg/g treatments. However, the 200-μg/g treatment significantly reduced yields, and the 400-μg/g treatment killed the plants, except at pH 8 where a single replicate survived (Figure 5). In the clay, yields were reduced in the 400-μg/g

Figure 5. *Cyperus esculentus* in the WES plant bioassay conducted with WRS in the pH study. Frames designated with the letters A through D in the lower right-hand corners were grown at pHs 5, 6, 7, and 8, respectively. Pots numbered 1 through 4 were treated with 0, 100, 200, and 400 μg TNT/g of soil (ODW), respectively

treatment at pH 5, but other treatments at all pH values exhibited no treatment effect (Figure 6). Results in Table 23 indicate higher yields from clay than from WRS in the 200- and 400-μg TNT/g treatments. The difference between plant growth in the two soils may be due to increased adsorption, which immobilizes TNT in the clay, thus ameliorating its effects. Effects of pH on yields were inconsistent among treatment levels.

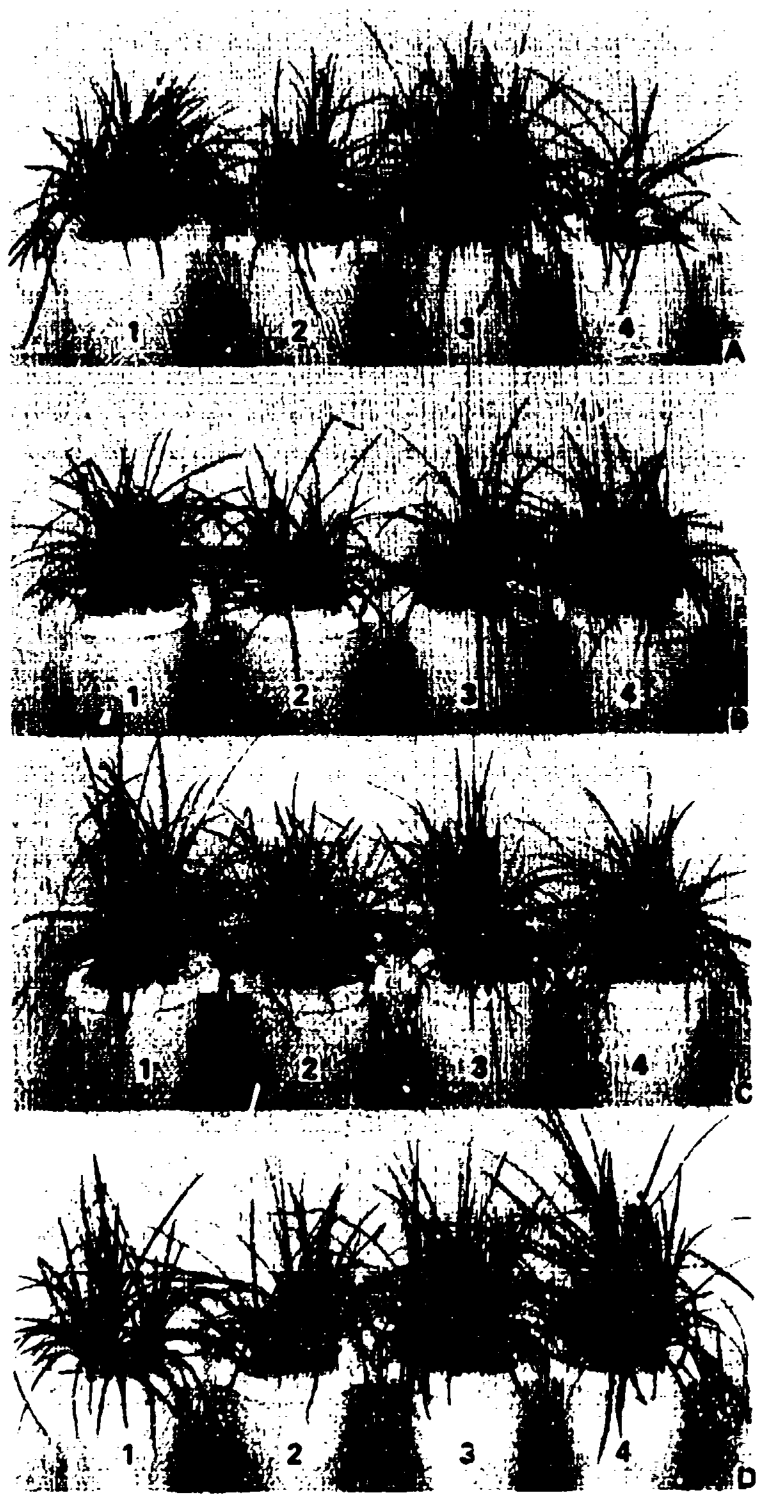

Figure 6. *Cyperus esculentus* in the WES plant bioassay conducted with clay in the pH study. Frames designated with the letters A through D in lower right-hand corners were grown at pHs 5, 6, 7, and 8, respectively. Pots numbered 1 through 4 were treated with 0, 100, 200, and 400 μg TNT/g of soil (ODW), respectively

PART IV: CONCLUSIONS

52. Conclusions of the study are summarized below:

   a. The soil extraction procedure developed by USATHAMA produced greater precision and accuracy than the procedure employed in the initial study.

   b. Concentrations of TNT declined dramatically in the WRS from the time of soil treatment to the end of the 65-day test period. The change may have been due to loss of TNT from the soil via volatilization. Degradation to 4ADNT and 2ADNT occurred rapidly after soil treatment and accounts for some of the loss, but concentrations of the two products were low.

   c. Insufficient plant uptake occurred to evaluate the effects of pH on plant uptake of TNT; however, plant yields tended to decrease with increasing pH in TNT-treated soils. The pH exerted only limited effects on soil concentrations of TNT, 4ADNT, or 2ADNT, while effects of pH on yields were inconsistent among treatment levels.

   d. Although data were insufficient to determine the effects of treatment levels on plant uptake of TNT, treatment levels exerted a dramatic effect on plant yields in the WRS. Plant yields decreased significantly at 200 μg TNT/g, and the plants from only one replicate survived in the 400-μg TNT/g treatment. Plant yields in clay were virtually unaffected by TNT treatment, presumably because greater adsorption of TNT to clay prevented mobilization to the plant.

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Table 1

Selected Physical and Chemical Properties of Soils Used in the Initial Study

Parameter	Soil-Type Test Results WRS	Silt	Clay
Particle-size distribution, %			
Sand	19.4 A*	20.0 A	8.8 B
Silt	69.4 A	67.5 A	37.0 B
Clay	11.2 B	12.5 B	54.2 A
pH	4.81 C	7.82 A	6.27 B
Lime requirement, kg/ha	4.37 A	0.00 C	2.24 B
CEC, meq/100 g	2.34 C	3.48 B	10.0 A
Organic matter, %	4.12 C	5.66 B	14.3 A

* Data represent means of four replicates. Means followed by the same letter in a row are not significantly different at $P < 0.05$ level of probability determined by Duncan's New Multiple Range Test.

Table 2

Percent Recoveries of TNT from Three Soils at T0

TNT Added µg/g	Soil Type* WRS	Silt	Clay
20	74.9 ± 58.3	71.5 ± 53.7	114 ± 40
40	77.5 ± 33.4	61.3 ± 36.1	52.5 ± 36.9

* Mean of four replicates ±1 standard deviation.

Table 3

Precision and Accuracy of Analytical Techniques for the Three Compounds of Interest

Parameter	Percent Recovery	Coefficient of Variation
TNT	80*	22
4ADNT	130	29
2ADNT	71	19

* Values given represent means of four determinations.

Table 4

Concentrations of TNT, 4ADNT, and 2ADNT Extracted from Three Soils at Three Incubation Times in the Initial Study

Extracted Contaminant	Incubation Time, days	TNT Added µg/g	Concentration by Soil Type, µg/g WRS		Silt		Clay	
TNT	0	0	<0.100	Ca*	<0.100	Ba	<0.100	Ba
		20	15.0	Ba	14.3	Aa	22.8	Aa
		40	31.0	Aa	24.5	Aa	21.0	Aa
	20	0	<0.100	Ba	<0.100	Ca	<0.100	Ba
		20	9.08	Aab	2.94	Bb	18.6	Aa
		40	8.45	Aa	14.3	Aa	18.4	Aa
	65	0	<0.23	Ba	<0.23	Ba	<0.28	Ba
		20	13.3	Aa	14.9	Aa	17.9	Aa
		40	34.0	Aa	1.09	Aa	26.8	Aa
4ADNT	0	0	<0.400	Ba	<0.400	Aa	<0.400	Aa
		20	0.445	ABa	2.18	Aa	<0.400	Aa
		40	2.43	Aa	0.638	Aab	<0.400	Ab
	20	0	<0.400	Ca	<0.400	Ca	<0.400	Ca
		20	5.93	Ba	1.65	Bb	5.48	Ba
		40	17.5	Aa	7.98	Ab	19.8	Aa
	65	0	<0.875	Ca	<0.230	Ba	<0.278	Ba
		20	19.5	Ba	17.1	Aa	37.3	Aa
		40	45.0	Aa	10.9	Ab	48.5	Aa
2ADNT	0	0	<0.200	Ba	0.200	Ba	<0.200	Aa
		20	0.215	Ba	0.215	Ba	0.215	Aa
		40	0.633	Aa	0.383	Aa	0.233	Ab
	20	0	<0.200	Ca	<0.200	Ba	<0.200	Ca
		20	1.04	Ba	<0.282	Bc	0.578	Bb
		40	1.85	Aa	0.525	Ab	15.9	Aa
	65	0	<0.233	Ca	<0.230	Ba	<0.278	Ba
		20	1.56	Ba	2.12	Aa	3.66	Aa
		40	4.05	Aa	0.873	Ab	4.58	Aa

* Data represent mean of four replicates. Means followed by the same upper case letter in a column within incubation times for each assayed compound are not significantly different at the $P < 0.05$ level. Means followed by the same lower case letter across soil type at each TNT treatment level are not significantly different at the $P < 0.05$ level. ANOVA and Waller-Duncan k-Ratio t-Test were performed on ranked data.

Table 5

Concentrations of TNT, 4ADNT, and 2ADNT in Plants from the Initial Study

Extracted Compound	TNT Treatment µg/g	Concentration by Soil Type, µg/g*		
		WRS	Silt	Clay
TNT	0	<1.64 ABa	<2.09 Aa	<2.09 ABa
	20	<1.10 Ba	<0.73 Ba	<0.82 Ba
	40	2.60 Aa	2.38 Aa	2.88 Aa
4ADNT	0	<1.67 Ba	<1.60 Ba	<1.19 Ba
	20	2.12 Ba	<1.06 Ba	1.42 Ba
	40	12.62 Aa	4.78 Aab	2.90 Ab
2ADNT	0	<1.30 Ba	<1.44 Aa	<1.12 Ba
	20	1.40 Ba	<0.73 Ba	<0.82 Ba
	40	2.75 Aa	2.12 Aa	1.80 Aa

* Data represent mean of four replicates. Means followed by the same upper case letter in a column within assayed compound are not significantly different at the $P < 0.05$ level. Means followed by the same lower case letter across soil type at each TNT treatment level are not significantly different at the $P < 0.05$ level. ANOVA and Waller-Duncan k-Ratio t-Test were performed on ranked data.

Table 6

Plant Yields for *Cyperus esculentus* Grown in Three Soils Treated with TNT in the Initial Study

TNT Added µg/g	Yield by Soil Type, g (ODW)/Pot		
	WRS	Silt	Clay
0	26.7 A*	21.3 A	32.6 A
20	**	**	**
40	28.0 A	27.4 A	28.2 A

* Data represent means of four replicates. Means followed by the same letter in a column are not significantly different at $P < 0.05$ level of probability determined by Duncan's New Multiple Range Test.

** Yield data were lost.

Table 7

Selected Physical and Chemical Properties of Soils Used in the pH Study

Parameter	Test Result by Soil Type: WRS	Clay
Particle-size distribution, %		
sand	9.4	8.7
silt	73.1	36.9
clay	17.5	54.4
pH	4.54	5.71
CEC, meq/100 g	3.56	24.1
Organic matter, %	4.02	14.8

Table 8

Percent Recoveries of TNT from Soils at T0 Illustrating Statistical Differences Between Recoveries at Various pH Values Within Soil Type at Each Treatment Level and Differences Between Recoveries at Each pH and Treatment Level Between Soil Types*

TNT Added µg/g	Soil pH	Soil Type--TNT Extracted, % of Added: WRS	CV†	Clay	CV
100	5	75.8 Ab**	8.17	103 Ba	4.88
	6	74.0 Ab	5.06	120 Aa	11.8
	7	76.8 Ab	2.23	103 Ba	4.88
	8	74.5 Ab	1.34	92.8 Ca	3.77
200	5	86.3 Ab	7.30	103 Aa	4.88
	6	90.0 Ab	7.86	100 Aa	8.17
	7	90.0 Aa	7.86	91.3 Ba	6.90
	8	82.5 Ab	7.82	92.5 Ba	3.12
400	5	84.3 Ab	9.49	108 Aa	7.87
	6	83.1 Aa	9.94	85.6 BCa	9.65
	7	88.8 Aa	10.7	93.8 Ba	6.35
	8	85.6 Aa	10.2	83.8 Ca	10.2

* Data contained in this table are the same as those contained in Table 9 but are arranged differently to illustrate statistical relationships.

** Data represent means of four replicates. Means followed by the same upper case letter in a column and within treatment level are not significantly different at $P < 0.05$ level of probability using orthogonal contrasts. Means followed by the same lower case letter in a row are not significantly different at $P < 0.05$ level of probability.

† CV = Coefficient of variation for the means.

Table 9

Percent Recoveries of TNT from Soils at T0 Illustrating Statistical Differences Between Recoveries at Various Treatment Levels Within pH and Soil Type*

Soil pH	TNT Added µg/g	Soil Type--TNT Extracted, % of Added: WRS	Soil Type--TNT Extracted, % of Added: Clay
5	100	75.8 B**	103 A
	200	86.3 A	103 A
	400	84.3 A	108 A
6	100	74.0 B	120 A
	200	90.0 A	100 B
	400	83.1 A	85.6 C
7	100	76.8 B	103 A
	200	90.0 A	91.3 B
	400	88.8 A	93.8 B
8	100	74.5 C	92.8 A
	200	82.5 B	92.5 A
	400	85.6 A	83.8 B

* Data contained in this table are the same as the data contained in Table 8. The data are arranged differently in the two tables to illustrate statistical relationships.

** Data represent means of four replicates. Means followed by the same letter in a column and within pH are not significantly different at the $P < 0.05$ level of probability using orthogonal contrasts.

Table 10

Precision and Accuracy of GLC Method Using Duplicates and Spikes of T0 Soils

Compound	Precision: WRS Concentration Range, µg/g	Precision: WRS Standard Deviation	Precision: Clay Concentration Range, µg/g	Precision: Clay Standard Deviation	Accuracy, % WRS	Accuracy, % Clay
TNT	68.0-380	±7.07	96.0-360	±14.1	102	101
2ADNT	0.0-3.6	±1.41	2.1-11.0	±2.75	100	96
4ADNT	0.0-6.5	±1.41	3.3-17.0	±6.22	100	94

Table 11

Soil Concentrations of TNT, 4ADNT, and 2ADNT at TO Illustrating Differences Among Treatment Levels*

Soil pH	TNT Added µg/g	TNT WRS Mean (S.E.)†	TNT Clay Mean (S.E.)	4ADNT WRS Mean (S.E.)	4ADNT Clay Mean (S.E.)	2ADNT WRS Mean (S.E.)	2ADNT Clay Mean (S.E.)
		Concentration of Compound by Soil Type, (µg/g)**, (Standard Error)					
5	0	1.75 (1.0) D	1.78 (0.94) D	<1.00 (0.0) C	<1.00 (0.0) C	<1.00 (0.0) B	<1.00 (0.0) C
	100	75.8 (3.1) C	102 (2.5) C	3.10 (0.082) C	3.42 (0.047) B	<1.00 (0.0) B	2.45 (0.087) B
	200	172 (6.3) B	205 (5.0) B	5.10 (0.15) B	6.32 (1.1) A	2.78 (0.29) A	5.22 (1.0) A
	400	338 (16) A	432 (17) A	8.62 (1.5) A	8.28 (0.15) A	3.82 (0.50) A	6.05 (0.096) A
6	0	<1.00 (0.0) D	1.75 (1.0) D	<1.00 (0.0) B	<1.00 (0.0) C	<1.00 (0.0) C	<1.00 (0.0) C
	100	74.0 (1.9) C	120 (7.1) C	1.95 (0.57) B	5.10 (1.1) B	1.25 (0.50) BC	4.08 (0.88) B
	200	180 (7.1) B	200 (8.2) B	5.20 (1.6) A	5.18 (0.34) B	2.22 (1.1) AB	4.42 (0.70) B
	400	332 (19) A	342 (16) A	6.28 (0.31) A	8.10 (0.23) A	3.00 (0.19) A	6.10 (0.12) A
7	0	<1.00 (0.0) D	<1.00 (0.0) D	<1.00 (0.0) C	<1.00 (0.0) C	<1.00 (0.0) B	<1.00 (0.0) D
	100	76.8 (0.85) C	102 (2.5) C	2.02 (0.025) BC	3.58 (0.025) B	<1.00 (0.0) B	2.72 (0.12) C
	200	180 (7.1) B	182 (6.3) B	3.35 (0.17) B	4.75 (0.065) B	<1.00 (0.0) B	3.68 (0.085) BC
	400	355 (19) A	375 (12) A	6.45 (0.16) A	11.1 (2.0) A	2.80 (0.071) A	7.38 (0.76) A
8	0	1.75 (1.0) D	<1.00 (0.0) D	<1.00 (0.0) C	<1.00 (0.0) C	<1.00 (0.0) B	<1.00 (0.0) C
	100	74.5 (0.50) C	92.8 (1.8) C	2.00 (0.0) BC	3.35 (0.050) B	<1.00 (0.0) B	2.68 (0.13) B
	200	165 (6.4) B	185 (2.9) B	3.05 (0.10) B	7.15 (2.3) A	<1.00 (0.0) B	5.60 (1.5) A
	400	342 (18) A	335 (17) A	7.30 (1.2) A	8.45 (0.27) A	4.22 (0.38) A	6.55 (0.18) A

* Data contained in this table are the same as the data contained in Table 12. The data are arranged differently in the two tables to illustrate statistical relationships.

** Means of four replicates. Means followed by the same letter in a column and within pH are not significantly different at the $P < 0.05$ level using orthogonal contrasts.

† Standard error of the mean.

Table 12

Concentrations of TNT, 4ADNT, and 2ADNT Extracted from Two Soils at Four pH Values and Four Treatment Levels Immediately After Treatment (T0) Illustrating Effects of pH and Soil Type*

TNT Added µg/g	Soil pH	TNT WRS	TNT Clay	4ADNT WRS	4ADNT Clay	2ADNT WRS	2ADNT Clay
0	5	1.75 Aa**	1.78 Aa	<1.00 Aa	<1.00 Aa	<1.00 Aa	<1.00 Aa
	6	<1.00 Aa	1.75 Aa	<1.00 Aa	<1.00 Aa	<1.00 Aa	<1.00 Aa
	7	<1.00 Aa	<1.00 Aa	<1.00 Aa	<1.00 Aa	<1.00 Aa	<1.00 Aa
	8	1.75 Aa	<1.00 Aa	<1.00 Aa	<1.00 Aa	<1.00 Aa	<1.00 Aa
100	5	75.8 Ab	102 ABa	3.10 Aa	3.42 Aa	<1.00 Ab	2.45 Ba
	6	74.0 Ab	120 Aa	1.95 Ab	5.10 Aa	1.25 Ab	4.08 Aa
	7	76.8 Ab	102 ABa	2.02 Aa	3.58 Aa	<1.00 Ab	2.72 Ba
	8	74.5 Ab	92.8 Ba	2.00 Aa	3.35 Aa	<1.00 Ab	2.68 Ba
200	5	172 Ab	205 Aa	5.10 Aa	6.32 ABa	2.78 Ab	5.22 Aa
	6	180 Aa	200 Aa	5.20 Aa	5.18 ABa	2.22 Ab	4.42 ABa
	7	180 Aa	182 Aa	3.35 Aa	4.75 Ba	1.00 Bb	3.68 Ba
	8	165 Aa	185 Aa	3.05 Ab	7.15 Aa	1.00 Bb	5.60 Aa
400	5	338 Ab	432 Aa	8.62 Aa	8.28 Ba	3.82 ABb	6.05 Aa
	6	332 Aa	342 Ca	6.28 Ba	8.10 Ba	3.00 ABb	6.10 Aa
	7	355 Aa	375 Ba	6.45 Bb	11.1 Aa	2.80 Bb	7.38 Aa
	8	342 Aa	335 Ca	7.30 ABa	8.45 Ba	4.22 Ab	6.55 Aa

* Data contained in this table are the same as the data contained in Table 11. The data are arranged differently in the two tables to illustrate statistical relationships.

** Means of four replicates. Means followed by the same upper case letter in a column and within TNT treatment level are not significantly different at the $P < 0.05$ level. Means followed by the same lower case letter across for each compound are not significantly different at the $P < 0.05$ level. Multiple comparisons were based on orthogonal contrasts.

Table 13

Soil Concentrations of TNT, 4ADNT, and 2ADNT at T20 Illustrating

Differences Among Treatment Levels*

Soil pH	TNT Added µg/g	Concentration of Compound by Soil Type, µg/g**, (Standard Error)											
		TNT				4ADNT				2ADNT			
		WRS		Clay		WRS		Clay		WRS		Clay	
		Mean (S.E.)†		Mean (S.E.)		Mean (S.E.)		Mean (S.E.)		Mean (S.E.)		Mean (S.E.)	
5	0	<1.00 (0.0)	C	<1.00 (0.0)	B	<1.00 (0.0)	C	<1.00 (0.0)	C	<1.00 (0.0)	C	1.08 (0.075)	D
	100	3.65 (1.2)	C	3.08 (0.12)	B	3.82 (0.74)	B	2.30 (0.75)	C	7.45 (0.72)	A	6.32 (1.5)	C
	200	81.5 (3.5)	B	4.70 (0.32)	B	5.70 (0.24)	A	7.08 (0.48)	B	6.65 (0.22)	AB	16.2 (1.0)	B
	400	278 (28)	A	99.5 (16)	A	6.22 (0.76)	A	21.0 (1.1)	A	4.75 (0.31)	B	27.8 (1.8)	A
6	0	<1.00 (0.0)	C	<1.00 (0.0)	B	1.15 (0.15)	C	<1.00 (0.0)	C	<1.00 (0.0)	C	1.10 (0.10)	D
	100	<1.00 (0.0)	C	2.95 (0.065)	B	3.45 (0.23)	B	1.52 (0.28)	C	7.08 (0.43)	B	4.08 (0.77)	C
	200	44.0 (7.2)	B	4.22 (0.31)	B	6.42 (0.28)	A	4.72 (0.37)	B	8.75 (0.87)	A	12.0 (1.4)	B
	400	238 (31)	A	52.8 (13)	A	3.82 (0.77)	B	16.0 (1.6)	A	3.32 (1.1)	C	31.5 (0.96)	A
7	0	<1.00 (0.0)	C	<1.00 (0.0)	A	<1.00 (0.0)	B	<1.00 (0.0)	C	<1.00 (0.0)	C	1.05 (0.050)	D
	100	<1.00 (0.0)	C	2.32 (0.048)	A	3.82 (0.10)	A	1.25 (0.087)	C	7.25 (0.30)	A	3.90 (0.24)	C
	200	55.2 (8.3)	B	3.05 (0.18)	A	4.48 (0.30)	A	3.10 (0.23)	B	4.95 (0.56)	AB	10.1 (0.84)	B
	400	202 (18)	A	29.5 (12)	A	4.58 (0.080)	A	15.2 (1.3)	A	4.22 (0.67)	B	31.2 (1.3)	A
8	0	<1.00 (0.0)	C	<1.00 (0.0)	A	<1.00 (0.0)	C	<1.00 (0.0)	C	<1.00 (0.0)	C	<1.00 (0.0)	C
	100	1.32 (0.32)	C	1.98 (0.33)	A	2.48 (0.75)	BC	1.05 (0.050)	C	5.50 (0.95)	AB	2.98 (0.63)	C
	200	40.7 (2.5)	B	3.20 (0.15)	A	5.47 (0.080)	A	2.52 (0.33)	B	7.23 (0.58)	A	8.48 (0.92)	B
	400	190 (23)	A	16.0 (1.3)	A	4.70 (1.3)	A	10.9 (1.3)	A	4.65 (1.8)	B	24.5 (1.8)	A

* Data contained in this table are the same as the data contained in Table 14. The data are arranged differently in the two tables to illustrate statistical relationships.

** Means of four replicates. Means followed by the same letter in a column and within pH are not significantly different at the $P < 0.05$ level. Multiple comparisons were made with orthogonal contrasts.

† Standard error of the mean.

Table 14

Concentration of TNT, 4ADNT, and 2ADNT Extracted from Two Soils at Four pH Values and Four Treatment Levels 20 Days After Treatment (T20) Illustrating Effects of pH and Soil Type*

TNT Added µg/g	Soil pH	TNT WRS	TNT Clay	4ADNT WRS	4ADNT Clay	2ADNT WRS	2ADNT Clay
0	5	<1.00 Aa**	<1.00 Aa	<1.00 Aa	<1.00 Aa	<1.00 Aa	<1.08 Aa
	6	<1.00 Aa	<1.00 Aa	1.15 Aa	<1.00 Aa	<1.00 Aa	1.10 Aa
	7	<1.00 Aa	<1.00 Aa	<1.00 Aa	<1.00 Aa	<1.00 Aa	1.05 Aa
	8	<1.00 Aa	<1.00 Aa	<1.00 Aa	<1.00 Aa	<1.00 Aa	<1.00 Aa
100	5	3.65 Aa	3.08 Aa	3.82 Aa	2.30 Ab	7.45 Aa	6.32 Ab
	6	<1.00 Aa	2.95 Aa	3.45 Aa	1.52 Ab	7.08 Aa	4.08 ABb
	7	<1.00 Aa	2.32 Aa	3.82 Aa	1.25 Ab	7.25 Aa	3.90 ABb
	8	1.32 Aa	1.98 Aa	2.48 Aa	1.05 Ab	5.50 Aa	2.98 Bb
200	5	81.5 Aa	4.70 Ab	5.70 Aa	7.08 Aa	6.65 ABb	16.2 Aa
	6	44.0 Ba	4.22 Ab	6.42 Aa	4.72 Ba	8.75 Ab	12.0 Ba
	7	55.2 ABa	3.05 Ab	4.48 Ba	3.10 BCa	4.95 Bb	10.1 BCa
	8	40.7 Ba	3.20 Aa	5.47 Aa	2.52 Cb	7.23 ABa	8.48 Ca
400	5	278 Aa	90.5 Ab	6.22 Ab	21.0 Aa	4.75 Ab	27.8 Ba
	6	238 Ba	52.8 Bb	3.82 Bb	16.0 Ba	3.32 Ab	31.5 Aa
	7	202 Ca	29.5 BCb	4.58 ABb	15.2 Ba	4.22 Ab	31.2 Aa
	8	190 Ca	16.0 Cb	4.70 ABb	10.9 Ca	4.65 Ab	24.5 Ca

* Data contained in this table are the same as the data contained in Table 13. The data are arranged differently in the two tables to illustrate statistical relationships.

** Data given are means of four replicates. Means followed by the same upper case letter in a column within TNT treatment level are not significantly different at the $P < 0.05$ level. Means followed by the same lower case letter across for each compound are not significantly different at the $P < 0.05$ level. Multiple comparisons were based on orthogonal contrasts.

Table 15

Soil Concentrations of TNT, 4ADNT, and 2ADNT at T65 Illustrating

Differences Among Treatment Levels

Soil pH	TNT Added µg/g	Concentration of Compound by Soil Type, (µg/g)**, (Standard Error)					
		TNT		4ADNT		2ADNT	
		WRS	Clay	WRS	Clay	WRS	Clay
		Mean (S.E.)†	Mean (S.E.)	Mean (S.E.)	Mean (S.E.)	Mean (S.E.)	Mean (S.E.)
5	0	<1.00 (0.0) B	<1.00 (0.0) B	<1.00 (0.0) C	<1.00 (0.0) C	<1.00 (0.0) C	<1.00 (0.0) C
	100	<1.00 (0.0) B	1.68 (0.68) AB	1.50 (0.50) C	2.35 (0.70) C	4.70 (0.71) C	3.88 (1.51) C
	200	1.48 (0.48) B	1.70 (0.70) AB	8.92 (1.3) B	5.80 (0.51) B	10.9 (1.4) B	7.70 (0.59) B
	400	52.8 (2.8) A	7.05 (0.33) A	16.8 (1.1) A	18.5 (0.96) A	14.8 (1.3) A	19.0 (1.1) A
6	0	<1.00 (0.0) B	<1.00 (0.0) B	<1.00 (0.0) C	<1.00 (0.0) C	<1.00 (0.0) C	<1.00 (0.0) C
	100	1.00 (0.0) B	<1.00 (0.0) B	1.16 (0.18) C	1.50 (0.29) BC	1.35 (0.22) C	2.18 (0.12) BC
	200	2.45 (1.4) B	1.35 (0.35) B	5.32 (1.6) B	3.58 (0.57) B	4.92 (1.5) B	4.20 (1.3) B
	400	30.8 (9.5) A	7.07 (0.51) A	12.2 (0.63) A	1[illegible].2 (1.2) A	11.0 (1.3) A	15.2 (0.85) A
7	0	<1.00 (0.0) B	<1.00 (0.0) A	<1.00 (0.0) B	<1.00 (0.0) B	<1.00 (0.0) C	<1.00 (0.0) B
	100	<1.00 (0.0) B	1.68 (0.68) A	<1.00 (0.0) B	<1.00 (0.0) B	<1.00 (0.0) C	1.78 (0.27) B
	200	<1.00 (0.0) B	1.68 (0.68) A	2.60 (0.69) B	2.25 (0.09) B	5.80 (1.4) B	3.90 (0.19) B
	400	8.80 (4.0) A	3.62 (0.92) A	11.0 (1.6) A	11.1 (0.72) A	13.0 (0.58) A	15.2 (0.95) A
8	0	<1.00 (0.0) A	<1.00 (0.0) A	<1.00 (0.0) C	<1.00 (0.0) B	<1.00 (0.0) C	<1.00 (0.0) B
	100	<1.00 (0.0) A	<1.00 (0.0) A	<1.00 (0.0) C	<1.00 (0.0) B	<1.00 (0.0) C	<1.00 (0.0) B
	200	<1.00 (0.0) A	<1.00 (0.0) A	4.55 (0.59) B	2.02 (0.37) B	8.32 (0.34) B	3.70 (0.31) B
	400	1.55 (0.16) A	4.25 (0.22) A	9.60 (1.2) A	7.98 (1.7) A	18.0 (3.8) A	12.3 (2.6) A

* Data contained in this table are the same as the data contained in Table 16. The data are arranged differently in the two tables to illustrate statistical relationships.

** Means of four replicates. Means followed by the same letter in a column and within pH are not significantly different at the $P < 0.05$ level. Multiple comparisons were made with orthogonal contrasts.

† Standard error of the mean.

Table 16

Concentration of TNT, 4ADNT, and 2ADNT Extracted from Two Soils at Four pH Values and Four Treatment Levels 65 Days After Treatment (T65) Illustrating Effects of pH and Soil Type*

TNT Added µg/g	Soil pH	Concentration of Compound by Soil Type, µg/g: TNT WRS	TNT Clay	4ADNT WRS	4ADNT Clay	2ADNT WRS	2ADNT Clay
0	5	<1.00 Aa**	<1.00 Aa	<1.00 Aa	<1.00 Aa	<1.00 Aa	<1.00 Aa
	6	<1.00 Aa	<1.00 Aa	<1.00 Aa	<1.00 Aa	<1.00 Aa	<1.00 Aa
	7	<1.00 Aa	<1.00 Aa	<1.00 Aa	<1.00 Aa	<1.00 Aa	<1.00 Aa
	8	<1.00 Aa	<1.00 Aa	<1.00 Aa	<1.00 Aa	<1.00 Aa	<1.00 Aa
100	5	<1.00 Aa	1.68 Aa	1.50 Aa	2.35 Aa	2.70 Aa	3.88 Aa
	6	<1.00 Aa	<1.00 Aa	1.18 Aa	1.50 ABa	1.35 Aa	2.18 ABa
	7	<1.00 Aa	1.68 Aa	<1.00 Aa	<1.00 Ba	<1.00 Aa	1.78 ABa
	8	<1.00 Aa	<1.00 Aa	<1.00 Aa	<1.00 Ba	<1.00 Aa	<1.00 Ba
200	5	1.48 Aa	<1.00 Aa	8.92 Aa	5.80 Ab	10.9 Aa	7.70 Ab
	6	2.45 Aa	1.35 Aa	5.32 Ba	3.58 Ba	4.92 Ca	4.20 Ba
	7	<1.00 Aa	1.68 Aa	2.60 Ca	2.25 Ba	5.80 BCa	3.90 Ba
	8	<1.00 Aa	<1.00 Aa	4.55 Ba	2.02 Bb	8.32 ABa	3.70 Bb
400	5	52.8 Aa	7.05 Ab	16.8 Aa	18.5 Aa	14.8 Bb	19.0 Aa
	6	30.8 Ba	7.07 Ab	12.2 Ba	11.2 Ba	11.0 Bb	15.2 Ba
	7	8.80 Ca	3.62 Aa	11.0 BCa	11.1 Ba	13.0 Ba	15.2 Ba
	8	1.55 Da	4.25 Aa	9.60 Ca	7.98 Ca	18.0 Aa	12.3 Bb

* Data contained in this table are the same as the data contained in Table 15. The data are arranged differently in the two tables to illustrate statistical relationships.

** Data represent means of four replicates. Means followed by the same upper case letter in a column within treatment level are not significantly different at the $P < 0.05$ level of probability. Means followed by the same lower case letter across each compound are not significantly different at the $P < 0.05$ level of probability. Multiple comparisons were based on orthogonal contrasts.

Table 17

Soil Concentrations of TNT Illustrating Changes Through Time

TNT Added µg/g	Soil pH	WRS T0		WRS T20		WRS T65		Clay T0		Clay T20		Clay T65	
0	5	1.75	A*	<1.00	A	<1.00	A	1.78	A	<1.00	A	<1.00	A
	6	<1.00	A	<1.00	A	<1.00	A	1.75	A	<1.00	A	<1.00	A
	7	<1.00	A	<1.00	A	<1.00	A	<1.00	A	<1.00	A	<1.00	A
	8	1.75	A	<1.00	A	<1.00	A	<1.00	A	<1.00	A	<1.00	A
100	5	75.8	A	3.65	B	<1.00	B	102	A	3.08	B	1.68	B
	6	74.0	A	<1.00	B	<1.00	B	120	A	2.95	B	<1.00	B
	7	76.8	A	<1.00	B	<1.00	B	102	A	2.32	B	1.68	B
	8	74.5	A	1.32	B	<1.00	B	92.8	A	1.98	B	<1.00	B
200	5	172	A	81.5	B	1.48	C	205	A	4.70	B	1.70	B
	6	180	A	44.0	B	2.45	C	200	A	4.22	B	1.35	B
	7	180	A	55.2	B	<1.00	C	182	A	3.05	B	1.68	B
	8	165	A	40.7	B	<1.00	C	185	A	3.20	B	<1.00	B
400	5	338	A	278	B	52.8	C	432	A	90.5	B	7.05	C
	6	332	A	238	B	30.8	C	342	A	52.8	B	7.07	C
	7	355	A	202	B	8.80	C	375	A	29.5	B	3.62	B
	8	342	A	190	B	1.55	C	335	A	16.0	B	4.25	B

Column header: Sampling Time, days; Concentration by Soil Type, µg/g

* Means of four replicates. Means followed by the same letter across and within soil type are not significantly different at the $P < 0.05$ level (Waller-Duncan k-Ratio t-Test).

Table 18

Soil Concentrations of 4ADNT Illustrating Changes Through Time

TNT Added µg/g	Soil pH	Sampling Time, days; Concentration by Soil Type, µg/g					
		WRS			Clay		
		T0	T20	T65	T0	T20	T65
0	5	<1.00 A*	<1.00 A	<1.00 A	<1.00 A	<1.00 A	<1.00 A
	6	<1.00 A	1.15 A	<1.00 A	<1.00 A	<1.00 A	<1.00 A
	7	<1.00 A	<1.00 A	<1.00 A	<1.00 A	<1.00 A	<1.00 A
	8	<1.00 A	<1.00 A	<1.00 A	<1.00 A	<1.00 A	<1.00 A
100	5	3.10 AB	3.82 A	1.50 B	3.42 A	2.30 A	2.35 A
	6	1.95 B	3.45 A	1.18 C	5.10 A	1.52 B	1.50 B
	7	2.02 B	3.82 A	<1.00 C	3.58 A	1.25 B	<1.00 C
	8	2.00 A	2.48 A	<1.00 A	3.35 A	1.05 B	<1.00 B
200	5	5.10 B	5.70 B	8.92 A	6.32 A	7.08 A	5.80 A
	6	5.20 A	6.42 A	5.32 A	5.18 A	4.72 AB	3.58 B
	7	3.35 AB	4.48 A	2.60 B	4.75 A	3.10 B	2.25 C
	8	3.05 B	5.47 A	4.55 A	7.15 A	2.52 AB	2.02 B
400	5	8.62 B	6.22 B	16.8 A	8.28 B	21.0 A	18.5 A
	6	6.28 B	3.82 C	12.2 A	8.10 B	16.0 A	11.2 B
	7	6.45 B	4.58 B	11.0 A	11.1 A	15.2 A	11.1 A
	8	7.30 AB	4.70 B	9.60 A	8.45 A	10.9 A	7.98 A

* Means of four replicates. Means followed by the same letter across and within soil type are not significantly different at the $P < 0.05$ level (Waller-Duncan k-Ratio t-Test).

Table 19

Soil Concentrations of 2ADNT Illustrating Changes Through Time

TNT Added µg/g	Soil pH	Sampling Time, days; Concentration by Soil Type, µg/g					
		WRS			Clay		
		T0	T20	T65	T0	T20	T65
0	5	<1.00 A*	<1.00 A	<1.00 A	<1.00 A	1.08 A	<1.00 A
	6	<1.00 A	<1.00 A	<1.00 A	<1.00 A	1.10 A	<1.00 A
	7	<1.00 A	<1.00 A	<1.00 A	<1.00 A	1.05 A	<1.00 A
	8	<1.00 A	<1.00 A	<1.00 A	<1.00 A	<1.00 A	<1.00 A
100	5	<1.00 B	7.45 A	2.70 B	2.45 B	6.32 A	3.88 AB
	6	1.25 B	7.08 A	1.35 B	4.08 A	4.08 A	2.18 A
	7	<1.00 B	7.25 A	<1.00 B	2.72 B	3.90 A	1.78 C
	8	<1.00 B	5.50 A	<1.00 B	2.68 A	2.98 A	<1.00 B
200	5	2.78 C	6.65 B	10.9 A	5.22 B	16.2 A	7.70 B
	6	2.22 B	8.75 A	4.92 B	4.42 B	12.0 A	4.20 B
	7	<1.00 B	4.95 A	5.80 A	3.68 B	10.1 A	3.90 B
	8	<1.00 B	7.23 A	8.32 A	5.60 AB	8.48 A	3.70 B
400	5	3.82 B	4.75 B	14.8 A	6.05 C	27.8 A	19.0 B
	6	3.00 B	3.32 B	11.0 A	6.10 C	31.5 A	15.2 B
	7	2.80 B	4.22 B	13.0 A	7.38 C	31.2 A	15.2 B
	8	4.22 B	4.65 B	18.0 A	6.55 B	24.5 A	12.3 B

* Means of four replicates. Means followed by the same letter across and within soil type are not significantly different at the $P < 0.05$ level (Waller-Duncan k-Ratio t-Test).

Table 20

Concentrations of TNT, 4ADNT, and 2ADNT in *Cyperus esculentus* Grown in Two Soils at Four pH Values and Four Levels of TNT Illustrating Effects of Treatment Level and Soil Type

Soil pH	TNT Added µg/g	Concentration of Compound by Soil Type, µg/g**, (Standard Error)					
		TNT		4ADNT		2ADNT	
		WRS	Clay	WRS	Clay	WRS	Clay
		Mean (S.E.)*	Mean (S.E.)	Mean (S.E.)	Mean (S.E.)	Mean (S.E.)	Mean (S.E.)
5	0	23.2 (1.7) Aa**	30.5 (1.4) Aa	0.00 (0.0) Aa	0.00 (0.0) Aa	0.00 (0.0) Aa	0.00 (0.0) Aa
	100	30.0 (2.4) Aa	32.2 (2.0) Aa	0.00 (0.0) Aa	1.75 (1.8) Aa	0.00 (0.0) Aa	0.00 (0.0) Aa
	200	50.0 (50.0) Aa	25.8 (1.0) Aa	6.25 (6.25) Aa	1.75 (1.8) Aa	0.00 (0.0) Aa	1.25 (1.2) Aa
	400	†	43.2 (24) A	†	3.75 (2.2) A	†	3.25 (1.9) A
6	0	25.0 (2.0) Aa	33.0 (3.9) Aa	0.00 (0.0) Ba	0.00 (0.0) Aa	0.00 (0.0) Aa	0.00 (0.0) Aa
	100	26.2 (2.4) Aa	28.0 (1.8) Aa	1.50 (1.5) ABa	1.50 (1.5) Aa	0.00 (0.0) Aa	0.00 (0.0) Aa
	200	25.2 (2.9) Aa	26.0 (4.6) Aa	4.75 (1.6) Aa	1.25 (1.3) Aa	1.75 (1.8) Aa	0.00 (0.0) Aa
	400	†	25.8 (3.0) A	†	4.00 (2.5) A	†	1.50 (1.5) A
7	0	24.2 (1.7) Aa	20.0 (0.71) Aa	1.25 (1.2) Aa	2.75 (1.6) Aa	0.00 (0.0) Aa	0.00 (0.0) Aa
	100	27.0 (2.4) Aa	28.5 (2.1) Aa	1.50 (1.5) Aa	0.00 (0.0) Aa	0.00 (0.0) Aa	0.00 (0.0) Aa
	200	26.2 (4.6) Aa	29.0 (4.3) Aa	4.75 (1.7) Aa	1.75 (1.8) Aa	3.25 (2.0) Aa	0.00 (0.0) Ab
	400	†	28.8 (5.3) A	†	1.50 (1.5) A	†	0.00 (0.0) Aa
8	0	21.0 (3.1) Aa	28.8 (1.0) Aa	0.00 (0.0) Aa	0.00 (0.0) Aa	0.00 (0.0) Aa	0.00 (0.0) Aa
	100	21.5 (2.5) Aa	26.2 (1.9) Aa	3.00 (1.7) Aa	0.00 (0.0) Aa	0.00 (0.0) Aa	0.00 (0.0) Aa
	200	6.00 (6.0) Aa††	26.8 (3.4) Aa	1.50 (1.5) Aa††	1.75 (1.8) Aa	0.00 (0.0) Aa††	0.00 (0.0) Aa
	400	23.8 (24) Aa‡	33.0 (3.9) Aa	0.00 (0.0) Aa‡	0.00 (0.0) Aa	0.00 (0.0) Aa‡	0.00 (0.0) Aa

* Standard error of the mean.

** Means of four replicates. Means followed by the same upper case letter in a column within pH are not significantly different at the $P < 0.05$ level. Means followed by the same lower case letter in a row for the same compound are not significantly different at the $P < 0.05$ level.

† No plants survived.

†† All plants in one of the four replicates died. Mean given treats the replicate of dead plants as 0 µg of assayed compound per gram of oven-dried plant material.

‡ Plants in only one of the four replicates survived. Mean given treats the replicates of dead plants as 0 µg of assayed compound per gram of oven-dried plant material.

Table 21

Concentrations of TNT, 4ADNT, and 2ADNT in *Cyperus esculentus* Grown in Two Soils at Four pH Values and Four Levels of TNT Illustrating Effects of pH at Each Treatment Level and for Each Assayed Compound by Soil Type

TNT Added µg/g	Soil pH	TNT WRS	TNT Clay	4ADNT WRS	4ADNT Clay	2ADNT WRS	2ADNT Clay
0	5	23.2 A*	30.5 A	0.00 A	0.00 A	0.00 A	0.00 A
	6	25.0 A	33.0 A	0.00 A	0.00 A	0.00 A	1.75 A
	7	24.2 A	20.0 B	1.25 A	2.75 A	0.00 A	0.00 A
	8	21.0 A	28.8 A	0.00 A	0.00 A	0.00 A	0.00 A
100	5	30.0 A	32.2 A	0.00 A	1.75 A	0.00 A	0.00 A
	6	26.2 A	28.0 A	1.50 A	1.50 A	0.00 A	0.00 A
	7	27.0 A	28.5 A	1.50 A	0.00 A	0.00 A	0.00 A
	8	21.5 A	26.2 A	3.00 A	0.00 A	0.00 A	0.00 A
200	5	50.0 A	25.8 A	6.25 A	1.75 A	0.00 A	1.25 A
	6	25.2 A	26.0 A	4.75 A	1.25 A	1.75 A	0.00 A
	7	26.2 A	29.0 A	4.75 A	1.75 A	3.25 A	0.00 A
	8	6.00 A**	26.8 A	1.50 A**	1.75 A	0.00 A**	0.00 A
400	5	†	43.2 A	†	3.75 A	†	3.25 A
	6	†	25.8 A	†	4.00 A	†	1.50 A
	7	†	28.8 A	†	1.50 A	†	0.00 A
	8	23.8††	33.0 A	0.00††	0.00 A	0.00††	0.00 A

* Means of four replicates. Means followed by the same upper case letter within treatment level are not significantly different at the $P < 0.05$ level using the Waller-Duncan k-Ratio t-Test.

** Plants in one of the four replicates died. Mean given treats replicates of the dead plants as 0 µg of assayed compound per gram of oven-dried plant material.

† No plants survived.

†† Plants in only one of the four replicates survived. Mean given treats the replicates of dead plants as 0 µg of assayed compound per gram of oven-dried plant material.

Table 22

Yields of *Cyperus esculentus* Grown in Two Soils at Four pH Values and Four TNT Treatment Levels Illustrating Effects of Treatment Levels

pH	TNT Added μg/g	Concentration by Soil Type, μg/g WRS	Clay
5	0	8.81 A*	8.21 A
	100	9.72 A	6.28 AB
	200	3.20 B	8.96 A
	400	**	3.73 A
6	0	8.84 A	7.25 A
	100	7.70 A	5.78 A
	200	5.17 B	5.73 A
	400	**	5.67 A
7	0	6.61 A	7.31 A
	100	7.38 A	6.47 A
	200	4.28 B	6.21 A
	400	**	5.77 A
8	0	8.99 A	6.56 A
	100	7.51 A	6.46 A
	200	3.08 B†	5.44 A
	400	1.02 C††	5.09 A

* Mean of four replicates. Means followed by the same upper case letter in a column within pH are not significantly different at $P < 0.05$ level.

** No plants survived.

† All plants in one of the four replicates died. Mean given treats the replicate of dead plants as 0 μg of assayed compound per gram of oven-dried plant material.

†† Plants in only one of the four replicates survived. Mean given treats the replicates of dead plants as 0 μg of assayed compound per gram of oven-dried plant material.

Table 23

Yields of *Cyperus esculentus* Grown in Two Soils at Four pH Values and Four TNT Treatment Levels Illustrating Effects of Treatment Levels

TNT Added µg/g	Soil pH	Soil Type-Yield, g (ODW)/Pot WRS	Clay
0	5	8.81 Aa*	8.21 Aa
	6	8.84 Aa	5.67 Bb
	7	6.61 Ba	5.77 Ba
	8	8.99 Aa	6.56 ABb
100	5	9.72 Aa	6.28 Ab
	6	7.70 Ba	5.73 Ab
	7	7.38 Ba	6.21 Aa
	8	7.51 Ba	5.09 Ab
200	5	3.20 Bb	8.96 Aa
	6	5.17 Ab	7.25 Ba
	7	4.28 ABb	7.31 ABa
	8	3.08 Bb**	5.44 Ba
400	5	†	3.73 B
	6	†	5.78 A
	7	†	6.47 A
	8	1.03 b††	6.48 Aa

* Means of four replicates. Means followed by the same upper case letter in a column within a TNT treatment level are not significantly different at $P < 0.05$ level. Means followed by the same lower case letter across soils at each treatment level are not significantly different at the $P < 0.05$ level.

** All plants in one of the four replicates died. Mean given treats the replicate of dead plants as 0 µg of assayed compound per gram of oven-dried plant material.

† No plants survived.

†† Plants in only one of the four replicates survived. Mean given treats the replicates of dead plants as 0 µg of assayed compound per gram of oven-dried plant material.

APPENDIX A: DATA

Table A1

Concentrations of TNT, 2ADNT, and 4ADNT in Soils at T0 in the Initial Study

Soil Type	TNT Added µg/g	Replicate	Compound Concentration, µg/g TNT	2ADNT	4ADNT
CLAY	0	1	<0.10	<0.20	<0.40
CLAY	0	2	<0.10	<0.20	<0.40
CLAY	0	3	<0.10	<0.20	<0.40
CLAY	0	4	<0.10	<0.20	<0.40
CLAY	20	1	34.00	0.26	<0.40
CLAY	20	2	21.00	<0.20	<0.40
CLAY	20	3	21.00	0.20	<0.40
CLAY	20	4	15.00	<0.20	<0.40
CLAY	40	1	13.00	<0.20	<0.40
CLAY	40	2	43.00	0.34	0.40
CLAY	40	3	16.00	0.20	0.40
CLAY	40	4	12.00	0.20	0.40
SILT	0	1	0.10	0.20	0.40
SILT	0	2	0.10	0.20	0.40
SILT	0	3	0.10	0.20	0.40
SILT	0	4	0.10	0.20	0.40
SILT	20	1	3.10	0.20	0.40
SILT	20	2	7.20	0.20	0.40
SILT	20	3	23.00	0.34	7.50
SILT	20	4	24.00	0.37	0.40
SILT	40	1	13.00	0.25	0.40
SILT	40	2	43.0	0.63	1.20
SILT	40	3	29.00	0.40	0.55
SILT	40	4	13.00	0.25	0.40
WRS	0	1	0.10	0.20	0.40
WRS	0	2	0.10	0.20	0.40
WRS	0	3	0.10	0.20	0.40
WRS	0	4	0.10	0.20	0.40
WRS	20	1	3.90	0.20	0.40
WRS	20	2	20.0	0.20	0.40
WRS	20	3	29.0	0.26	0.58
WRS	20	4	7.00	0.20	0.40
WRS	40	1	51.0	0.84	3.30
WRS	40	2	24.0	0.90	3.70
WRS	40	3	24.0	0.20	0.40
WRS	40	4	25.0	0.59	2.30

Table A2

Concentrations of TNT, 2ADNT, and 4ADNT in Soils at T20 in the Initial Study

Soil Type	TNT Added µg/g	Replicate	Compound Concentration, µg/g TNT	2ADNT	4ADNT
CLAY	0	1	0.10	0.20	0.40
CLAY	0	2	0.10	0.20	0.40
CLAY	0	3	0.10	0.20	0.40
CLAY	0	4	0.10	0.20	0.40
CLAY	20	1	11.0	0.20	0.40
CLAY	20	2	45.0	0.80	5.80
CLAY	20	3	9.50	1.00	8.00
CLAY	20	4	8.90	0.31	7.70
CLAY	40	1	3.10	58.0	10.0
CLAY	40	2	38.0	2.30	27.0
CLAY	40	3	7.60	1.60	20.0
CLAY	40	4	25.0	1.80	22.0
SILT	0	1	0.10	0.20	0.40
SILT	0	2	0.10	0.20	0.40
SILT	0	3	0.10	0.20	0.40
SILT	0	4	0.10	0.20	0.40
SILT	20	1	0.10	0.20	0.40
SILT	20	2	6.40	0.20	2.70
SILT	20	3	3.10	0.20	2.40
SILT	20	4	0.16	0.20	1.10
SILT	40	1	12.0	0.40	6.80
SILT	40	2	12.0	0.59	8.70
SILT	40	3	22.0	0.66	9.40
SILT	40	4	11.0	0.45	7.00
WRS	0	1	0.10	0.20	0.40
WRS	0	2	0.10	0.20	0.40
WRS	0	3	0.10	0.20	0.40
WRS	0	4	0.10	0.20	0.40
WRS	20	1	2.10	1.00	4.50
WRS	20	2	1.30	0.78	6.70
WRS	20	3	26.0	1.50	6.00
WRS	20	4	6.90	0.89	6.50
WRS	40	1	23.0	2.70	22.0
WRS	40	2	1.50	1.70	13.0
WRS	40	3	0.69	1.30	20.0
WRS	40	4	0.60	1.70	15.0

Table A3

Concentrations of TNT, 2ADNT, and 4ADNT in Soils at T65 in the Initial Study

Soil Type	TNT Added µg/g	Replicate	Compound Concentration, µg/g TNT	2ADNT	4ADNT
CLAY	0	1	0.26	0.26	0.26
CLAY	0	2	0.29	0.29	0.29
CLAY	0	3	0.27	0.27	0.27
CLAY	0	4	0.29	0.29	0.29
CLAY	20	1	70.0	12.0	110.0
CLAY	20	2	0.57	1.00	18.0
CLAY	20	3	0.47	0.75	8.10
CLAY	20	4	0.54	0.89	13.00
CLAY	40	1	0.70	1.80	28.00
CLAY	40	2	73.0	9.80	93.00
CLAY	40	3	0.57	1.30	20.00
CLAY	40	4	33.0	5.40	53.00
SILT	0	1	0.25	0.25	0.25
SILT	0	2	0.20	0.20	0.25
SILT	0	3	0.24	0.24	0.24
SILT	0	4	0.23	0.23	0.23
SILT	20	1	17.0	2.90	21.00
SILT	20	2	0.71	0.46	2.40
SILT	20	3	0.71	0.42	1.90
SILT	20	4	41.0	4.70	43.00
SILT	40	1	0.66	0.90	13.00
SILT	40	2	2.60	1.00	8.70
SILT	40	3	0.47	0.59	4.70
SILT	40	4	0.64	1.00	17.00
WRS	0	1	0.23	0.23	2.80
WRS	0	2	0.23	0.23	0.23
WRS	0	3	0.23	0.23	0.23
WRS	0	4	0.24	0.24	0.24
WRS	20	1	5.10	1.20	14.00
WRS	20	2	0.27	0.26	3.90
WRS	20	3	47.0	3.90	42.00
WRS	20	4	0.77	0.89	18.00
WRS	40	1	0.62	2.20	32.00
WRS	40	2	2.40	1.60	20.00
WRS	40	3	34.0	4.40	48.00
WRS	40	4	99.0	8.00	80.00

Table A4

Concentrations of TNT, 2ADNT, and 4ADNT in *Cyperus esculentus* Grown in Clay, Silt, and WRS Treated with 0, 20, and 40 μg TNT/g of Soil in the Initial Study

Soil Type	TNT Added μg/g	Replicate	Compound Concentration, μg/g		
			TNT	2ADNT	4ADNT
CLAY	0	1	0.77	0.77	0.77
		2	3.50	1.80	1.50
		3	3.40	1.50	1.50
		4	0.69	0.69	0.69
CLAY	20	1	0.83	0.83	0.83
		2	0.83	2.40	0.83
		3	0.83	0.83	0.83
		4	0.80	1.60	0.80
CLAY	40	1	2.90	2.10	1.80
		2	2.70	3.10	1.50
		3	3.20	2.60	1.50
		4	2.70	3.80	2.40
SILT	0	1	2.50	2.20	1.60
		2	0.87	0.87	0.87
		3	2.90	1.70	1.70
		4	2.10	1.60	1.60
SILT	20	1	0.64	0.64	0.64
		2	0.71	0.71	0.71
		3	0.87	0.87	0.87
		4	0.71	2.00	0.71
SILT	40	1	1.90	5.00	2.10
		2	2.30	5.50	2.10
		3	2.90	4.50	2.70
		4	2.40	4.10	1.60
WRS	0	1	1.30	1.80	1.30
		2	2.20	2.40	1.40
		3	2.30	1.70	1.70
		4	0.77	0.77	0.77
WRS	20	1	2.00	4.30	3.20
		2	0.77	1.20	0.77
		3	0.80	1.70	0.80
		4	0.83	1.30	0.83
WRS	40	1	2.90	18.0	3.30
		2	2.90	12.0	2.60
		3	2.40	9.50	2.70
		4	2.20	11.0	2.70

Table A5

Concentrations of TNT, 2ADNT, and 4ADNT in Soils at TO in the pH Study

Soil Type	TNT Added µg/g	Soil pH	Replicate	Compound Concentration, µg/g TNT	2ADNT	4ADNT
CLAY	0	5	1	4.0	<1.0	<1.0
CLAY	0	5	2	<1.0	<1.0	<1.0
CLAY	0	5	3	<1.0	<1.0	<1.0
CLAY	0	5	4	1.1	<1.0	<1.0
CLAY	0	6	1	<1.0	<1.0	<1.0
CLAY	0	6	2	<1.0	<1.0	<1.0
CLAY	0	6	3	<1.0	<1.0	<1.0
CLAY	0	6	4	4.0	<1.0	<1.0
CLAY	0	7	1	<1.0	<1.0	<1.0
CLAY	0	7	2	<1.0	<1.0	<1.0
CLAY	0	7	3	<1.0	<1.0	<1.0
CLAY	0	7	4	<1.0	<1.0	<1.0
CLAY	0	8	1	<1.0	<1.0	<1.0
CLAY	0	8	2	<1.0	<1.0	<1.0
CLAY	0	8	3	<1.0	<1.0	<1.0
CLAY	0	8	4	<1.0	<1.0	<1.0
WRS	0	5	1	4.0	<1.0	<1.0
WRS	0	5	2	<1.0	<1.0	<1.0
WRS	0	5	3	<1.0	<1.0	<1.0
WRS	0	5	4	<1.0	<1.0	<1.0
WRS	0	6	1	<1.0	<1.0	<1.0
WRS	0	6	2	<1.0	<1.0	<1.0
WRS	0	6	3	<1.0	<1.0	<1.0
WRS	0	6	4	<1.0	<1.0	<1.0
WRS	0	7	1	<1.0	<1.0	<1.0
WRS	0	7	2	<1.0	<1.0	<1.0
WRS	0	7	3	<1.0	<1.0	<1.0
WRS	0	7	4	<1.0	<1.0	<1.0
WRS	0	8	1	4.0	<1.0	<1.0
WRS	0	8	2	<1.0	<1.0	<1.0
WRS	0	8	3	<1.0	<1.0	<1.0
WRS	0	8	4	<1.0	<1.0	<1.0
CLAY	100	5	1	110.0	2.5	3.3
CLAY	100	5	2	100.0	2.6	3.5
CLAY	100	5	3	100.0	2.2	3.5
CLAY	100	5	4	100.0	2.5	3.4
CLAY	100	6	1	120.0	6.7	8.4
CLAY	100	6	2	110.0	3.1	3.9
CLAY	100	6	3	110.0	3.1	3.8
CLAY	100	6	4	140.0	3.4	4.3
CLAY	100	7	1	100.0	2.7	3.6
CLAY	100	7	2	110.0	2.8	3.6

(Continued)

(Sheet 1 of 3)

Table A5 (Continued)

Soil Type	TNT Added µg/g	Soil pH	Replicate	Compound Concentration, µg/g TNT	2ADNT	4ADNT
CLAY	100	7	3	100.0	3.0	3.5
CLAY	100	7	4	100.0	2.4	3.6
CLAY	100	8	1	91.0	2.7	3.3
CLAY	100	8	2	98.0	2.9	3.5
CLAY	100	8	3	91.0	2.3	3.3
CLAY	100	8	4	91.0	2.8	3.3
WRS	100	5	1	72.0	<1.0	3.1
WRS	100	5	2	85.0	<1.0	3.3
WRS	100	5	3	73.0	<1.0	3.1
WRS	100	5	4	73.0	<1.0	2.9
WRS	100	6	1	75.0	<1.0	2.3
WRS	100	6	2	74.0	<1.0	2.2
WRS	100	6	3	78.0	<1.0	2.3
WRS	100	6	4	69.0	2.0	<1.0
WRS	100	7	1	76.0	<1.0	2.0
WRS	100	7	2	77.0	<1.0	2.0
WRS	100	7	3	75.0	<1.0	2.0
WRS	100	7	4	79.0	<1.0	2.1
WRS	100	8	1	74.0	<1.0	2.0
WRS	100	8	2	74.0	<1.0	2.0
WRS	100	8	3	76.0	<1.0	2.0
WRS	100	8	4	74.0	<1.0	2.0
CLAY	200	5	1	220.0	7.9	9.6
CLAY	200	5	2	200.0	3.7	5.2
CLAY	200	5	3	200.0	5.8	5.7
CLAY	200	5	4	200.0	3.5	4.8
CLAY	200	6	1	220.0	6.5	6.2
CLAY	200	6	2	200.0	4.0	4.9
CLAY	200	6	3	200.0	3.7	4.9
CLAY	200	6	4	180.0	3.5	4.7
CLAY	200	7	1	180.0	3.9	4.7
CLAY	200	7	2	180.0	3.6	4.8
CLAY	200	7	3	170.0	3.5	4.6
CLAY	200	7	4	200.0	3.7	4.9
CLAY	200	8	1	190.0	10.0	14.0
CLAY	200	8	2	180.0	4.4	5.1
CLAY	200	8	3	180.0	3.7	4.5
CLAY	200	8	4	190.0	4.3	5.0
WRS	200	5	1	170.0	2.5	5.1
WRS	200	5	2	190.0	2.7	5.5
WRS	200	5	3	160.0	2.3	4.8
WRS	200	5	4	170.0	3.6	5.0
WRS	200	6	1	200.0	4.4	10.0
WRS	200	6	2	170.0	<1.0	3.7

(Continued)

(Sheet 2 of 3)

Table A5 (Concluded)

Soil Type	TNT Added µg/g	Soil pH	Replicate	Compound Concentration, µg/g TNT	2ADNT	4ADNT
WRS	200	6	3	170.0	2.5	3.6
WRS	200	6	4	180.0	<1.0	3.5
WRS	200	7	1	180.0	<1.0	3.1
WRS	200	7	2	170.0	<1.0	3.1
WRS	200	7	3	200.0	<1.0	3.4
WRS	200	7	4	170.0	<1.0	3.8
WRS	200	8	1	180.0	<1.0	3.3
WRS	200	8	2	170.0	<1.0	3.1
WRS	200	8	3	150.0	<1.0	2.8
WRS	200	8	4	160.0	<1.0	3.0
CLAY	400	5	1	390.0	5.8	7.9
CLAY	400	5	2	420.0	6.0	8.2
CLAY	400	5	3	460.0	6.2	8.6
CLAY	400	5	4	460.0	6.2	8.4
CLAY	400	6	1	340.0	6.1	8.0
CLAY	400	6	2	300.0	5.8	7.6
CLAY	400	6	3	380.0	6.4	8.7
CLAY	400	6	4	350.0	6.1	8.1
CLAY	400	7	1	360.0	9.6	17.0
CLAY	400	7	2	400.0	7.0	9.9
CLAY	400	7	3	390.0	6.6	9.1
CLAY	400	7	4	350.0	6.3	8.3
CLAY	400	8	1	340.0	6.9	8.9
CLAY	400	8	2	380.0	6.8	8.9
CLAY	400	8	3	300.0	6.2	7.8
CLAY	400	8	4	320.0	6.3	8.2
WRS	400	5	1	310.0	5.3	13.0
WRS	400	5	2	370.0	3.5	7.7
WRS	400	5	3	360.0	3.4	7.2
WRS	400	5	4	310.0	3.1	6.6
WRS	400	6	1	340.0	2.9	6.1
WRS	400	6	2	290.0	2.6	5.6
WRS	400	6	3	320.0	3.5	7.1
WRS	400	6	4	380.0	3.0	6.3
WRS	400	7	1	300.0	2.6	6.0
WRS	400	7	2	360.0	2.9	6.7
WRS	400	7	3	380.0	2.9	6.6
WRS	400	7	4	380.0	2.8	6.5
WRS	400	8	1	360.0	5.0	11.0
WRS	400	8	2	380.0	3.2	6.5
WRS	400	8	3	330.0	4.4	5.9
WRS	400	8	4	300.0	4.3	5.8

(Sheet 3 of 3)

Table A6

Concentrations of TNT, 2ADNT, and 4ADNT in Soils at T20 in the pH Study

Soil Type	TNT Added µg/g	Soil pH	Replicate	Compound Concentration, µg/g TNT	2ADNT	4ADNT
CLAY	0	5	1	<1.0	<1.0	<1.0
CLAY	0	5	2	<1.0	1.3	<1.0
CLAY	0	5	3	<1.0	<1.0	<1.0
CLAY	0	5	4	<1.0	<1.0	<1.0
CLAY	0	6	1	<1.0	1.4	<1.0
CLAY	0	6	2	<1.0	<1.0	<1.0
CLAY	0	6	3	<1.0	<1.0	<1.0
CLAY	0	6	4	<1.0	<1.0	<1.0
CLAY	0	7	1	<1.0	<1.0	<1.0
CLAY	0	7	2	<1.0	1.2	<1.0
CLAY	0	7	3	<1.0	<1.0	<1.0
CLAY	0	7	4	<1.0	<1.0	<1.0
CLAY	0	8	1	<1.0	<1.0	<1.0
CLAY	0	8	2	<1.0	<1.0	<1.0
CLAY	0	8	3	<1.0	<1.0	<1.0
CLAY	0	8	4	<1.0	<1.0	<1.0
WRS	0	5	1	<1.0	<1.0	<1.0
WRS	0	5	2	<1.0	<1.0	<1.0
WRS	0	5	3	<1.0	<1.0	<1.0
WRS	0	5	4	<1.0	<1.0	<1.0
WRS	0	6	1	<1.0	<1.0	<1.0
WRS	0	6	2	<1.0	<1.0	<1.0
WRS	0	6	3	<1.0	<1.0	<1.0
WRS	0	6	4	<1.0	<1.0	1.6
WRS	0	7	1	<1.0	<1.0	<1.0
WRS	0	7	2	<1.0	<1.0	<1.0
WRS	0	7	3	<1.0	<1.0	<1.0
WRS	0	7	4	<1.0	<1.0	<1.0
WRS	0	8	1	<1.0	<1.0	<1.0
WRS	0	8	2	<1.0	<1.0	<1.0
WRS	0	8	3	<1.0	<1.0	<1.0
WRS	0	8	4	<1.0	<1.0	<1.0
CLAY	100	5	1	3.4	9.6	3.7
CLAY	100	5	2	2.9	5.5	<1.0
CLAY	100	5	3	2.9	2.6	<1.0
CLAY	100	5	4	3.1	7.6	3.5
CLAY	100	6	1	2.8	2.3	<1.0
CLAY	100	6	2	3.1	3.6	1.3
CLAY	100	6	3	3.0	6.0	2.3
CLAY	100	6	4	2.9	4.4	1.5
CLAY	100	7	1	2.4	4.2	1.3
CLAY	100	7	2	2.3	3.4	1.3

(Continued)

(Sheet 1 of 3)

Table A6 (Continued)

Soil Type	TNT Added µg/g	Soil pH	Replicate	Compound Concentration, µg/g TNT	2ADNT	4ADNT
CLAY	100	7	3	2.2	4.4	1.4
CLAY	100	7	4	2.4	3.6	<1.0
CLAY	100	8	1	2.3	4.3	1.2
CLAY	100	8	2	2.2	1.4	<1.0
CLAY	100	8	3	2.4	3.6	<1.0
CLAY	100	8	4	<1.0	2.6	<1.0
WRS	100	5	1	3.8	6.5	3.2
WRS	100	5	2	2.9	7.4	2.7
WRS	100	5	3	6.9	6.4	3.4
WRS	100	5	4	<1.0	9.5	6.0
WRS	100	6	1	<1.0	6.1	3.1
WRS	100	6	2	<1.0	6.9	3.2
WRS	100	6	3	<1.0	8.2	4.1
WRS	100	6	4	<1.0	7.1	3.4
WRS	100	7	1	<1.0	7.6	3.6
WRS	100	7	2	<1.0	6.6	3.7
WRS	100	7	3	<1.0	6.9	4.0
WRS	100	7	4	<1.0	7.9	4.0
WRS	100	8	1	<1.0	7.3	4.0
WRS	100	8	2	<1.0	3.1	<1.0
WRS	100	8	3	<1.0	6.7	3.5
WRS	100	8	4	2.3	4.9	1.4
CLAY	200	5	1	4.1	14.0	6.1
CLAY	200	5	2	4.3	18.0	7.8
CLAY	200	5	3	5.5	18.0	8.0
CLAY	200	5	4	4.9	15.0	6.4
CLAY	200	6	1	4.2	13.0	5.2
CLAY	200	6	2	5.0	14.0	5.3
CLAY	200	6	3	4.2	7.9	3.7
CLAY	200	6	4	3.5	13.0	4.7
CLAY	200	7	1	2.8	8.5	2.6
CLAY	200	7	2	2.7	8.9	2.8
CLAY	200	7	3	3.5	11.0	3.5
CLAY	200	7	4	3.2	12.0	3.5
CLAY	200	8	1	2.9	11.0	3.4
CLAY	200	8	2	3.1	7.9	2.5
CLAY	200	8	3	3.6	6.6	1.8
CLAY	200	8	4	3.2	8.4	2.4
WRS	200	5	1	90.0	6.1	5.1
WRS	200	5	2	--	--	--
WRS	200	5	3	--	--	--
WRS	200	5	4	73.0	7.2	6.3
WRS	200	6	1	34.0	10.0	6.8
WRS	200	6	2	41.0	10.0	6.8

(Continued)

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Table A6 (Concluded)

Soil Type	TNT Added µg/g	Soil pH	Replicate	Compound Concentration, µg/g TNT	2ADNT	4ADNT
WRS	200	6	3	36.0	8.7	6.5
WRS	200	6	4	65.0	6.3	5.6
WRS	200	7	1	48.0	6.0	5.3
WRS	200	7	2	38.0	5.8	4.5
WRS	200	7	3	58.0	3.7	3.9
WRS	200	7	4	77.0	4.3	4.2
WRS	200	8	1	40.0	6.0	5.3
WRS	200	8	2	35.0	8.8	5.7
WRS	200	8	3	47.0	6.9	5.4
WRS	200	8	4	--	--	--
CLAY	400	5	1	42.0	33.0	24.0
CLAY	400	5	2	110.0	25.0	19.0
CLAY	400	5	3	110.0	26.0	21.0
CLAY	400	5	4	100.0	27.0	20.0
CLAY	400	6	1	40.0	33.0	14.0
CLAY	400	6	2	24.0	29.0	13.0
CLAY	400	6	3	81.0	31.0	20.0
CLAY	400	6	4	66.0	33.0	17.0
CLAY	400	7	1	17.0	30.0	13.0
CLAY	400	7	2	17.0	31.0	15.0
CLAY	400	7	3	64.0	29.0	19.0
CLAY	400	7	4	20.0	35.0	14.0
CLAY	400	8	1	13.0	20.0	8.3
CLAY	400	8	2	19.0	28.0	13.0
CLAY	400	8	3	17.0	23.0	9.3
CLAY	400	8	4	15.0	27.0	13.0
WRS	400	5	1	240.0	5.3	7.3
WRS	400	5	2	340.0	4.7	7.0
WRS	400	5	3	310.0	5.1	6.6
WRS	400	5	4	220.0	3.9	4.0
WRS	400	6	1	250.0	1.5	2.5
WRS	400	6	2	160.0	1.9	2.7
WRS	400	6	3	230.0	6.4	5.8
WRS	400	6	4	310.0	3.5	4.3
WRS	400	7	1	150.0	5.5	4.7
WRS	400	7	2	210.0	5.0	4.5
WRS	400	7	3	230.0	3.9	4.4
WRS	400	7	4	220.0	2.5	4.7
WRS	400	8	1	230.0	5.9	5.2
WRS	400	8	2	230.0	1.7	2.7
WRS	400	8	3	150.0	1.7	2.6
WRS	400	8	4	150.0	9.3	8.3

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Table A7

Concentrations of TNT, 2ADNT, and 4ADNT in Soils at T65 in the pH Study

Soil Type	TNT Added μg/g	Soil pH	Replicate	Compound Concentration, μg/g TNT	2ADNT	4ADNT
CLAY	0	5	1	<1.0	<1.0	<1.0
CLAY	0	5	2	<1.0	<1.0	<1.0
CLAY	0	5	3	<1.0	<1.0	<1.0
CLAY	0	5	4	<1.0	<1.0	<1.0
CLAY	0	6	1	<1.0	<1.0	<1.0
CLAY	0	6	2	<1.0	<1.0	<1.0
CLAY	0	6	3	<1.0	<1.0	<1.0
CLAY	0	6	4	<1.0	<1.0	<1.0
CLAY	0	7	1	<1.0	<1.0	<1.0
CLAY	0	7	2	<1.0	<1.0	<1.0
CLAY	0	7	3	<1.0	1.8	<1.0
CLAY	0	7	4	<1.0	<1.0	<1.0
CLAY	0	8	1	<1.0	<1.0	<1.0
CLAY	0	8	2	<1.0	<1.0	<1.0
CLAY	0	8	3	<1.0	<1.0	<1.0
CLAY	0	8	4	<1.0	<1.0	<1.0
WRS	0	5	1	<1.0	<1.0	<1.0
WRS	0	5	2	<1.0	<1.0	<1.0
WRS	0	5	3	<1.0	<1.0	<1.0
WRS	0	5	4	<1.0	<1.0	<1.0
WRS	0	6	1	<1.0	<1.0	<1.0
WRS	0	6	2	<1.0	<1.0	<1.0
WRS	0	6	3	<1.0	<1.0	<1.0
WRS	0	6	4	<1.0	<1.0	<1.0
WRS	0	7	1	<1.0	<1.0	<1.0
WRS	0	7	2	<1.0	<1.0	<1.0
WRS	0	7	3	<1.0	<1.0	<1.0
WRS	0	7	4	<1.0	<1.0	<1.0
WRS	0	8	1	<1.0	<1.0	<1.0
WRS	0	8	2	<1.0	<1.0	<1.0
WRS	0	8	3	<1.0	<1.0	<1.0
WRS	0	8	4	<1.0	<1.0	<1.0
CLAY	100	5	1	<1.0	5.2	2.9
CLAY	100	5	2	3.7	3.9	2.4
CLAY	100	5	3	<1.0	2.7	2.0
CLAY	100	5	4	<1.0	3.7	2.1
CLAY	100	6	1	<1.0	1.9	<1.0
CLAY	100	6	2	<1.0	2.2	<1.0
CLAY	100	6	3	<1.0	2.5	2.0
CLAY	100	6	4	<1.0	2.1	2.0
CLAY	100	7	1	<1.0	2.1	<1.0
CLAY	100	7	2	3.7	1.8	<1.0

(Continued)

(Sheet 1 of 3)

Table A7 (Continued)

Soil Type	TNT Added µg/g	Soil pH	Replicate	Compound Concentration, µg/g TNT	2ADNT	4ADNT
CLAY	100	7	3	<1.0	2.2	<1.0
CLAY	100	7	4	<1.0	<1.0	<1.0
CLAY	100	8	1	<1.0	<1.0	<1.0
CLAY	100	8	2	<1.0	<1.0	<1.0
CLAY	100	8	3	<1.0	<1.0	<1.0
CLAY	100	8	4	<1.0	<1.0	<1.0
WRS	100	5	1	<1.0	1.6	<1.0
WRS	100	5	2	<1.0	1.8	<1.0
WRS	100	5	3	<1.0	4.7	3.0
WRS	100	5	4	<1.0	2.7	<1.0
WRS	100	6	1	<1.0	<1.0	1.7
WRS	100	6	2	<1.0	1.5	<1.0
WRS	100	6	3	<1.0	1.9	<1.0
WRS	100	6	4	<1.0	<1.0	<1.0
WRS	100	7	1	<1.0	<1.0	<1.0
WRS	100	7	2	<1.0	<1.0	<1.0
WRS	100	7	3	<1.0	<1.0	<1.0
WRS	100	7	4	<1.0	<1.0	<1.0
WRS	100	8	1	<1.0	<1.0	<1.0
WRS	100	8	2	<1.0	<1.0	<1.0
WRS	100	8	3	<1.0	<1.0	<1.0
WRS	100	8	4	<1.0	<1.0	<1.0
CLAY	200	5	1	<1.0	7.9	5.2
CLAY	200	5	2	<1.0	9.3	7.3
CLAY	200	5	3	<1.0	6.8	5.1
CLAY	200	5	4	3.8	6.8	5.6
CLAY	200	6	1	2.4	<1.0	4.2
CLAY	200	6	2	<1.0	7.2	4.8
CLAY	200	6	3	<1.0	3.6	2.3
CLAY	200	6	4	<1.0	5.0	3.0
CLAY	200	7	1	<1.0	3.9	2.1
CLAY	200	7	2	<1.0	4.0	2.4
CLAY	200	7	3	<1.0	3.4	2.1
CLAY	200	7	4	3.7	4.3	2.4
CLAY	200	8	1	<1.0	4.4	2.6
CLAY	200	8	2	<1.0	2.9	<1.0
CLAY	200	8	3	<1.0	3.8	2.5
CLAY	200	8	4	<1.0	3.7	2.0
WRS	200	5	1	<1.0	10.0	7.5
WRS	200	5	2	2.9	14.0	12.0
WRS	200	5	3	<1.0	12.0	10.0
WRS	200	5	4	<1.0	7.6	6.2
WRS	200	6	1	<1.0	8.5	5.0
WRS	200	6	2	<1.0	4.7	3.5

(Continued)

(Sheet 2 of 3)

Table A7 (Concluded)

Soil Type	TNT Added µg/g	Soil pH	Replicate	Compound Concentration, µg/g TNT	2ADNT	4ADNT
WRS	200	6	3	6.8	<1.0	10.0
WRS	200	6	4	<1.0	5.5	2.8
WRS	200	7	1	<1.0	3.1	<1.0
WRS	200	7	2	<1.0	6.6	3.8
WRS	200	7	3	<1.0	4.1	1.9
WRS	200	7	4	<1.0	9.4	3.7
WRS	200	8	1	<1.0	7.8	4.1
WRS	200	8	2	<1.0	9.3	3.7
WRS	200	8	3	<1.0	8.2	6.3
WRS	200	8	4	<1.0	8.0	4.1
CLAY	400	5	1	7.1	19.0	18.0
CLAY	400	5	2	7.5	21.0	20.0
CLAY	400	5	3	7.5	20.0	20.0
CLAY	400	5	4	6.1	16.0	16.0
CLAY	400	6	1	7.2	15.0	9.8
CLAY	400	6	2	6.0	13.0	8.8
CLAY	400	6	3	8.4	17.0	14.0
CLAY	400	6	4	6.7	16.0	12.0
CLAY	400	7	1	4.2	15.0	11.0
CLAY	400	7	2	4.0	18.0	11.0
CLAY	400	7	3	5.3	14.0	13.0
CLAY	400	7	4	<1.0	14.0	9.5
CLAY	400	8	1	3.9	9.1	6.0
CLAY	400	8	2	4.8	20.0	13.0
CLAY	400	8	3	3.9	11.0	6.4
CLAY	400	8	4	4.4	9.0	6.5
WRS	400	5	1	48.0	15.0	15.0
WRS	400	5	2	59.0	16.0	16.0
WRS	400	5	3	48.0	11.0	20.0
WRS	400	5	4	56.0	17.0	16.0
WRS	400	6	1	41.0	9.3	12.0
WRS	400	6	2	19.0	12.0	14.0
WRS	400	6	3	11.0	14.0	12.0
WRS	400	6	4	52.0	8.5	11.0
WRS	400	7	1	1.3	12.0	7.6
WRS	400	7	2	5.5	12.0	9.4
WRS	400	7	3	20.0	14.0	12.0
WRS	400	7	4	8.4	14.0	15.0
WRS	400	8	1	1.3	12.0	7.1
WRS	400	8	2	<1.0	15.0	9.4
WRS	400	8	3	2.9	29.0	13.0
WRS	400	8	4	<1.0	16.0	8.9

(Sheet 3 of 3)

Table A8

Yields of *Cyperus esculentus* Grown in WRS and Clay Treated with 0, 100, 200, and 400 μg TNT/g of Soil at Four pH Values

Soil Type	TNT Added	Soil pH	Rep*	% Dry wt	Total Live wet wt, g	Dead ODW, g	Total Live dry wt, g	Total Live ODW, g
CLAY	0	5	1	15	80.2	5.9	12.0	11.6
CLAY	0	5	2	14	104.4	0.1	14.6	6.2
CLAY	0	5	3	19	84.5	1.6	16.1	5.9
CLAY	0	5	4	17	94.0	4.3	16.0	9.2
CLAY	0	6	1	15	57.0	0.4	8.6	6.1
CLAY	0	6	2	22	52.7	0.6	11.6	4.1
CLAY	0	6	3	20	62.0	2.5	12.4	6.5
CLAY	0	6	4	15	83.3	0.3	12.5	6.0
CLAY	0	7	1	20	74.0	2.9	14.8	6.9
CLAY	0	7	2	23	36.0	0.7	8.3	4.0
CLAY	0	7	3	23	60.0	4.8	13.8	8.1
CLAY	0	7	4	24	33.2	0.8	8.0	4.0
CLAY	0	8	1	14	19.0	0.7	2.7	6.8
CLAY	0	8	2	15	52.2	0.4	7.8	6.1
CLAY	0	8	3	15	77.3	2.0	11.6	7.7
CLAY	0	8	4	16	56.6	0.4	9.1	5.7
CLAY	100	5	1	15	41.8	0.5	6.3	6.2
CLAY	100	5	2	16	46.0	2.0	7.4	7.3
CLAY	100	5	3	14	96.3	0.9	13.5	7.0
CLAY	100	5	4	18	29.0	0.1	5.2	4.7
CLAY	100	6	1	16	139.0	1.1	22.2	6.4
CLAY	100	6	2	18	52.6	1.5	9.5	6.1
CLAY	100	6	3	15	43.3	0.2	6.5	5.9
CLAY	100	6	4	23	61.7	1.3	14.2	4.6
CLAY	100	7	1	14	28.5	0.7	4.0	6.8
CLAY	100	7	2	19	56.2	1.5	10.7	5.8
CLAY	100	7	3	17	18.2	1.1	3.1	6.0
CLAY	100	7	4	14	33.2	0.1	4.6	6.2
CLAY	100	8	1	19	62.0	1.7	11.8	6.0
CLAY	100	8	2	16	31.3	0.0	5.0	5.3
CLAY	100	8	3	19	40.0	0.0	7.6	4.3
CLAY	100	8	4	17	60.7	0.0	10.3	4.9
CLAY	200	5	1	17	57.0	3.1	9.7	8.0
CLAY	200	5	2	20	53.7	4.6	10.7	8.6
CLAY	200	5	3	21	73.3	4.5	15.4	8.3
CLAY	200	5	4	20	89.2	7.0	17.8	11.0
CLAY	200	6	1	24	52.0	5.6	12.5	8.8

(Continued)

* Rep = replicate.

(Sheet 1 of 4)

Table A8 (Continued)

Soil Type	TNT Added	Soil pH	Rep*	% Dry wt	Total Live wet wt, g	Dead ODW, g	Total Live dry wt, g	Total Live ODW, g
CLAY	200	6	2	13	78.8	0.2	10.2	6.9
CLAY	200	6	3	19	90.5	3.4	17.2	7.7
CLAY	200	6	4	17	101.1	0.8	17.2	5.7
CLAY	200	7	1	18	51.2	1.6	9.2	6.2
CLAY	200	7	2	19	78.7	4.1	15.0	8.4
CLAY	200	7	3	22	62.7	4.2	13.8	7.7
CLAY	200	7	4	13	60.2	0.3	7.8	7.0
CLAY	200	8	1	16	68.7	0.2	11.0	5.5
CLAY	200	8	2	20	88.0	0.8	17.6	4.8
CLAY	200	8	3	16	61.8	1.6	9.9	6.9
CLAY	200	8	4	23	24.0	1.3	5.5	4.6
CLAY	400	5	1	16	24.2	0.0	3.9	5.3
CLAY	400	5	2	20	11.6	0.0	2.3	4.0
CLAY	400	5	3	15	1.7	0.0	0.3	5.7
CLAY	400	5	4	--	0.0	0.0	0.0	0.0
CLAY	400	6	1	16	40.0	1.2	6.4	6.5
CLAY	400	6	2	22	58.5	0.8	12.9	4.3
CLAY	400	6	3	21	45.6	1.0	9.6	4.8
CLAY	400	6	4	16	60.5	2.3	9.7	7.6
CLAY	400	7	1	13	46.0	0.0	6.0	6.7
CLAY	400	7	2	21	28.8	0.7	6.0	4.5
CLAY	400	7	3	12	38.3	0.0	4.6	7.3
CLAY	400	7	4	13	72.8	0.7	9.5	7.4
CLAY	400	8	1	17	76.5	0.8	13.0	5.7
CLAY	400	8	2	12	40.7	0.0	4.9	7.3
CLAY	400	8	3	18	38.5	1.0	6.9	5.6
CLAY	400	8	4	12	36.6	0.0	4.4	7.3
WRS	0	5	1	16	72.0	4.0	11.5	9.2
WRS	0	5	2	14	51.2	4.0	7.2	10.1
WRS	0	5	3	19	42.0	4.0	8.0	8.2
WRS	0	5	4	21	26.0	4.0	5.5	7.7
WRS	0	6	1	18	62.3	4.0	11.2	8.5
WRS	0	6	2	19	41.1	4.0	7.8	8.2
WRS	0	6	3	14	54.6	4.0	7.6	10.1
WRS	0	6	4	18	59.5	4.0	10.7	8.5
WRS	0	7	1	19	52.0	2.9	9.9	7.2
WRS	0	7	2	16	59.8	2.1	9.6	7.4
WRS	0	7	3	19	60.5	0.5	11.5	4.8
WRS	0	7	4	17	67.8	2.3	11.5	7.2
WRS	0	8	1	18	61.5	1.3	11.1	5.9
WRS	0	8	2	30	37.3	8.6	11.2	10.9
WRS	0	8	3	15	55.0	3.4	8.3	9.1
WRS	0	8	4	20	40.4	6.1	8.1	10.1

(Continued)

(Sheet 2 of 4)

Table A8 (Continued)

Soil Type	TNT Added	Soil pH	Rep*	% Dry wt	Total Live wet wt, g	Dead ODW, g	Total Live dry wt, g	Total Live ODW, g
WRS	100	5	1	18	44.7	5.6	8.0	10.2
WRS	100	5	2	13	74.0	1.1	9.6	7.8
WRS	100	5	3	13	23.0	3.4	3.0	10.1
WRS	100	5	4	14	65.7	4.7	9.2	10.8
WRS	100	6	1	20	59.4	2.1	11.9	6.1
WRS	100	6	2	16	48.4	4.6	7.7	9.9
WRS	100	6	3	13	56.0	0.6	7.3	7.3
WRS	100	6	4	19	37.0	3.3	7.0	7.6
WRS	100	7	1	18	67.3	1.6	12.1	6.2
WRS	100	7	2	14	59.8	2.4	8.4	8.5
WRS	100	7	3	18	45.7	3.2	8.2	7.8
WRS	100	7	4	15	60.8	1.4	9.1	7.1
WRS	100	8	1	19	42.0	2.1	8.0	6.4
WRS	100	8	2	27	24.5	5.1	6.6	7.8
WRS	100	8	3	17	45.5	2.8	7.7	7.7
WRS	100	8	4	20	48.5	4.2	9.7	8.2
WRS	200	5	1	--	0.0	0.0	0.0	0.0
WRS	200	5	2	20	0.7	0.2	0.1	4.2
WRS	200	5	3	20	1.2	0.3	0.2	4.3
WRS	200	5	4	20	0.1	0.3	0.0	4.3
WRS	200	6	1	20	9.0	0.2	1.8	4.2
WRS	200	6	2	13	29.4	0.2	3.8	6.9
WRS	200	6	3	20	6.0	0.3	1.2	4.3
WRS	200	6	4	17	18.0	0.4	3.1	5.3
WRS	200	7	1	20	3.3	0.3	0.7	4.3
WRS	200	7	2	20	6.6	0.0	1.3	4.0
WRS	200	7	3	20	9.7	0.5	1.9	4.5
WRS	200	7	4	20	11.4	0.3	2.3	4.3
WRS	200	8	1	--	0.0	0.0	0.0	0.0
WRS	200	8	2	20	9.0	0.2	1.8	4.2
WRS	200	8	3	20	0.1	0.1	0.0	4.1
WRS	200	8	4	20	1.5	0.0	0.3	4.0
WRS	400	5	1	--	0.0	0.0	0.0	0.0
WRS	400	5	2	--	0.0	0.0	0.0	0.0
WRS	400	5	3	--	0.0	0.0	0.0	0.0
WRS	400	5	4	--	0.0	0.0	0.0	0.0
WRS	400	6	1	--	0.0	0.0	0.0	0.0
WRS	400	6	2	--	0.0	0.0	0.0	0.0
WRS	400	6	3	--	0.0	0.0	0.0	0.0
WRS	400	6	4	--	0.0	0.0	0.0	0.0
WRS	400	7	1	--	0.0	0.0	0.0	0.0
WRS	400	7	2	--	0.0	0.0	0.0	0.0
WRS	400	7	3	--	0.0	0.0	0.0	0.0

(Continued)

(Sheet 3 of 4)

Table A8 (Concluded)

Soil Type	TNT Added	Soil pH	Rep*	% Dry wt	Total Live wet wt, g	Dead ODW, g	Total Live dry wt, g	Total Live ODW, g
WRS	400	7	4	--	0.0	0.0	0.0	0.0
WRS	400	8	1	--	0.0	0.0	0.0	0.0
WRS	400	8	2	--	0.0	0.0	0.0	0.0
WRS	400	8	3	--	0.0	0.0	0.0	0.0
WRS	400	8	4	20	1.0	0.1	0.2	4.1

(Sheet 4 of 4)

Table A9

Concentrations of TNT, 2ADNT, and 4ADNT in *Cyperus esculentus* Grown in WRS and Clay Treated with 0, 100, 200, and 400 μg TNT/g of Soil at Four pH values

Soil Type	TNT Added μg/g	Soil pH	Replicate	Compound Concentration, μg/g TNT	2ADNT	4ADNT
CLAY	0	5	1	31.0	<7.0	<7.0
CLAY	0	5	2	34.0	<7.0	<7.0
CLAY	0	5	3	27.0	<5.0	<5.0
CLAY	0	5	4	30.0	<6.0	<6.0
CLAY	0	6	1	39.0	<7.0	<7.0
CLAY	0	6	2	29.0	<5.0	<5.0
CLAY	0	6	3	24.0	<5.0	<5.0
CLAY	0	6	4	40.0	<7.0	<7.0
CLAY	0	7	1	22.0	<5.0	6.0
CLAY	0	7	2	19.0	<4.0	5.0
CLAY	0	7	3	20.0	<4.0	<4.0
CLAY	0	7	4	19.0	<4.0	<4.0
CLAY	0	8	1	29.0	<7.0	<7.0
CLAY	0	8	2	31.0	<7.0	<7.0
CLAY	0	8	3	29.0	<7.0	<7.0
CLAY	0	8	4	26.0	<6.0	<6.0
CLAY	100	5	1	29.0	<7.0	<7.0
CLAY	100	5	2	29.0	<6.0	<6.0
CLAY	100	5	3	34.0	<7.0	<7.0
CLAY	100	5	4	37.0	<6.0	7.0
CLAY	100	6	1	31.0	<6.0	<6.0
CLAY	100	6	2	26.0	<6.0	<6.0
CLAY	100	6	3	31.0	<7.0	<7.0
CLAY	100	6	4	24.0	<4.0	6.0
CLAY	100	7	1	33.0	<7.0	<7.0
CLAY	100	7	2	25.0	<5.0	<5.0
CLAY	100	7	3	25.0	<6.0	<6.0
CLAY	100	7	4	31.0	<7.0	<7.0
CLAY	100	8	1	25.0	<5.0	<5.0
CLAY	100	8	2	24.0	<6.0	<6.0
CLAY	100	8	3	24.0	<5.0	<5.0
CLAY	100	8	4	32.0	<6.0	<6.0
CLAY	200	5	1	26.0	<6.0	<6.0
CLAY	200	5	2	28.0	5.0	7.0
CLAY	200	5	3	23.0	<5.0	<5.0
CLAY	200	5	4	26.0	<5.0	<5.0
CLAY	200	6	1	17.0	<4.0	5.0
CLAY	200	6	2	38.0	<8.0	<8.0
CLAY	200	6	3	21.0	<5.0	<5.0

(Continued)

(Sheet 1 of 4)

Table A9 (Continued)

Soil Type	TNT Added µg/g	Soil pH	Replicate	Compound Concentration, µg/g TNT	2ADNT	4ADNT
CLAY	200	6	4	28.0	<6.0	<6.0
CLAY	200	7	1	29.0	<6.0	<6.0
CLAY	200	7	2	25.0	<5.0	<5.0
CLAY	200	7	3	21.0	<5.0	7.0
CLAY	200	7	4	41.0	<7.0	<7.0
CLAY	200	8	1	32.0	<6.0	<6.0
CLAY	200	8	2	27.0	<5.0	<5.0
CLAY	200	8	3	31.0	<6.0	7.0
CLAY	200	8	4	17.0	<4.0	<4.0
CLAY	400	5	1	38.0	7.0	8.0
CLAY	400	5	2	25.0	6.0	7.0
CLAY	400	5	3	110.0	<20.0	<20.0
CLAY	400	5	4	*	*	*
CLAY	400	6	1	28.0	<6.0	<6.0
CLAY	400	6	2	20.0	6.0	10.0
CLAY	400	6	3	22.0	<5.0	6.0
CLAY	400	6	4	33.0	<6.0	<6.0
CLAY	400	7	1	18.0	<7.0	<7.0
CLAY	400	7	2	22.0	<5.0	6.0
CLAY	400	7	3	34.0	<8.0	<8.0
CLAY	400	7	4	41.0	<8.0	<8.0
CLAY	400	8	1	28.0	<6.0	<6.0
CLAY	400	8	2	43.0	<8.0	<8.0
CLAY	400	8	3	26.0	<6.0	<6.0
CLAY	400	8	4	35.0	<8.0	<8.0
WRS	0	5	1	25.0	<6.0	<6.0
WRS	0	5	2	27.0	<7.0	<7.0
WRS	0	5	3	21.0	<5.0	<5.0
WRS	0	5	4	20.0	<5.0	<5.0
WRS	0	6	1	22.0	<6.0	<6.0
WRS	0	6	2	23.0	<5.0	<5.0
WRS	0	6	3	31.0	<7.0	<7.0
WRS	0	6	4	24.0	<6.0	<6.0
WRS	0	7	1	21.0	<5.0	5.0
WRS	0	7	2	28.0	<6.0	<6.0
WRS	0	7	3	22.0	<5.0	<5.0
WRS	0	7	4	26.0	<6.0	<6.0
WRS	0	8	1	23.0	<6.0	<6.0
WRS	0	8	2	13.0	<3.0	<3.0
WRS	0	8	3	28.0	<7.0	<7.0
WRS	0	8	4	20.0	<5.0	<5.0

(Continued)

* Plants did not survive.

(Sheet 2 of 4)

Table A9 (Continued)

Soil Type	TNT Added µg/g	Soil pH	Replicate	Compound Concentration, µg/g TNT	2ADNT	4ADNT
WRS	100	5	1	23.0	<6.0	<6.0
WRS	100	5	2	34.0	<8.0	<8.0
WRS	100	5	3	32.0	<7.0	<7.0
WRS	100	5	4	31.0	<7.0	<7.0
WRS	100	6	1	24.0	<5.0	<5.0
WRS	100	6	2	26.0	<6.0	<6.0
WRS	100	6	3	33.0	<8.0	<8.0
WRS	100	6	4	22.0	<5.0	6.0
WRS	100	7	1	23.0	<6.0	6.0
WRS	100	7	2	33.0	<7.0	<7.0
WRS	100	7	3	23.0	<6.0	<6.0
WRS	100	7	4	29.0	<7.0	<7.0
WRS	100	8	1	21.0	<5.0	6.0
WRS	100	8	2	15.0	<4.0	<4.0
WRS	100	8	3	27.0	<6.0	<6.0
WRS	100	8	4	23.0	<5.0	6.0
WRS	200	5	1	*	*	*
WRS	200	5	2	200.0	<50.0	<50.0
WRS	200	5	3	<25.0	<25.0	25.0
WRS	200	5	4	<500.0	<500.0	<500.0
WRS	200	6	1	19.0	7.0	7.0
WRS	200	6	2	33.0	<8.0	<8.0
WRS	200	6	3	24.0	<5.0	6.0
WRS	200	6	4	25.0	<6.0	6.0
WRS	200	7	1	40.0	<10.0	<0.0
WRS	200	7	2	23.0	5.0	8.0
WRS	200	7	3	20.0	<5.0	6.0
WRS	200	7	4	12.0	8.0	5.0
WRS	200	8	1	*	*	*
WRS	200	8	2	24.0	<5.0	6.0
WRS	200	8	3	<250.0	<250.0	<250.0
WRS	200	8	4	<15.0	<15.0	<15.0
WRS	400	5	1	*	*	*
WRS	400	5	2	*	*	*
WRS	400	5	3	*	*	*
WRS	400	5	4	*	*	*
WRS	400	6	1	*	*	*
WRS	400	6	2	*	*	*
WRS	400	6	3	*	*	*
WRS	400	6	4	*	*	*
WRS	400	7	1	*	*	*

(Continued)

* Plants did not survive.

(Sheet 3 of 4)

Table A9 (Concluded)

Soil Type	TNT Added µg/g	Soil pH	Replicate	Compound Concentration, µg/g TNT	2ADNT	4ADNT
WRS	400	7	2	*	*	*
WRS	400	7	3	*	*	*
WRS	400	7	4	*	*	*
WRS	400	8	1	*	*	*
WRS	400	8	2	*	*	*
WRS	400	8	3	*	*	*
WRS	400	8	4	95.0	<25.0	<25.0

* Plants did not survive.

(Sheet 4 of 4)